Review of Criteria for Selecting Ecologically Significant Areas of the Scotian Shelf and Slope

A Discussion Paper

Prepared for:
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FOREWORD

The Oceans and Coastal Management Division (OCMD), Maritimes Region, Fisheries and Oceans Canada, has released this paper to help move the discussion forward on ecological areas requiring special consideration within the context of integrated ocean management. The primary intent of this paper is to foster discussion on criteria for ecological significance and their application to the Scotian Shelf and Slope. In doing so, it is hoped that this discussion paper will provide a useful contribution to regional integrated ocean management and marine conservation efforts. In particular, this discussion paper is relevant to the ongoing development of ecosystem objectives and the identification of conservation priorities for the Eastern Scotian Shelf Integrated Management (ESSIM) Initiative. Similarly, it may provide useful information for related marine conservation efforts in Maritimes Region, including the developing Marine Protected Areas program.

This paper was prepared by Heather Breeze (Maris Consulting) in August 2003. The report does not represent a formal review or an official position of Fisheries and Oceans Canada. A number of reviewers provided comments on an earlier version. A wide variety of opinions on specific merits or issues related to the selection criteria and approach discussed in this paper exist. However, there is widespread agreement that this is an important and timely topic. This discussion paper is now offered to a wider audience in the interest of promoting such discussion. It should be noted that the content has not been updated to reflect any management measures or information published subsequent to the summer of 2003. Future work could include another review of the criteria suggested in this paper and more detailed analysis of the available data to apply and test the selected criteria. Your comments on this report and the possible next steps concerning the identification of ecologically significant areas are welcomed.

We would like to thank Christie Chute, Ralph Halliday, Gareth Harding, Marty King, Robert O'Boyle, Murray Rudd, Nancy Shackell, Robert Siron, John Tremblay, and Darren Williams for their comments. We would also like to thank Lesley Carter for preparing many of the maps found in this paper.

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1.0 INTRODUCTION – BACKDROP TO THIS DISCUSSION PAPER

Canada's *Oceans Act* came into effect in 1997 and provided the framework for a new era of oceans management in Canada. The Act seeks to promote the sustainable development of Canada's oceans and promote conservation, including the development of integrated management plans and a national system of marine protected areas (MPAs). There are currently two *Oceans Act* projects on the Scotian Shelf: The Gully MPA and the Eastern Scotian Shelf Integrated Management (ESSIM) Initiative.

This discussion paper was prepared to support *Oceans Act* projects and effective oceans planning on the Scotian Shelf. The goal of this paper is to further discussion on criteria that should be used in selecting areas of ecological significance on the Scotian Shelf and Slope (not including coastal areas). There are several purposes for developing criteria and selecting areas of ecological significance:

- to identify areas that may require special management measures to conserve their special features, such as through integrated management or other management processes;
- to identify areas that may require special consideration in the environmental assessment of activities proposed for the Scotian Shelf;
- to further discussion on defining areas that may meet the criteria for marine protected areas as listed under Section 35 of Canada's *Oceans Act;* and
- to assist with the development of an ecosystem objectives framework for the ESSIM Initiative, given that many ecosystem objectives require indicators with a spatial element concerning species and habitat significance.

This discussion paper sets out criteria and a method for identifying areas of ecological significance. It then applies the method to the Scotian Shelf and Slope. Actual areas that correspond to one or more of the criteria are then described in short profiles. Much of the discussion on identifying ecologically important areas in the literature is rather abstract, with potential selection processes and criteria often described in detail but less often applied to actual areas. These concrete examples are intended to demonstrate the application of criteria and to inspire discussion on which criteria are more or less appropriate for selecting ecologically significant areas of the Scotian Shelf and Slope. As well, it may inspire discussion on how to conserve ecologically significant areas in general.

Some of the areas profiled were identified as ecologically significant in other works. Areas not previously identified in the literature are profiled here based on the extensive reading about the Scotian Shelf by the author undertaken for the "The Scotian Shelf: An ecological overview for ocean planning" (Breeze *et al.* 2002) and the "Natural Environment of the Eastern Scotian Shelf Large Oceans Management Area" (Appendix 1 in OCMD 2003). The profiles do not constitute a comprehensive listing of all ecologically significant areas, but a listing based on the author's analysis using selected indicators for ecological significance. Evaluations by others may add to or take away from the list of indicators or the list of potentially ecologically significant areas.

Agardy *et al.* (2003) point to the importance of using appropriate management tools to achieve marine conservation objectives. There are many tools that are or could be used to conserve and manage marine resources off Canada. For example, the *Oceans Act* provides for the development of integrated management plans for large ocean management areas and a national system of marine protected areas. The Eastern Scotian Shelf Integrated Management (ESSIM) Initiative is a collaborative planning project that will lead to an integrated management

plan for the area. Several government departments, ocean industries and environmental organizations are involved in the development of the plan. Although still in the preliminary stages, there is potential for the plan to address cumulative effects of activities, to harmonize management processes for particular areas, to identify areas requiring specialized management measures, to assist in the development of "best practice" guidelines for industries, and to set environmental quality standards across sectors (OCMD 2003).

Other tools currently being used to protect marine resources include sector-specific regulations and guidelines. The *Fisheries Act* has long been used to set fishing regulations for particular areas of Canada's offshore, including quotas, seasonal and year-round closures, and gear restrictions. For the petroleum industry, the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) implements regulations that determine how oil and gas activities are to be conducted in Nova Scotia's marine environment. It has also requested that companies develop "Codes of Practice" when working near The Gully or Sable Island.

Thus, there are a variety of tools that could be used to ensure the features of ecologically significant areas are maintained. ***The areas profiled later in the document should not automatically be considered future marine protected areas. While some of them may merit further research, evaluation and consideration by DFO's Marine Protected Areas Program, their characteristics and significance have not been thoroughly reviewed by DFO scientists. As well, some of these areas already have management measures aimed at protecting the special features of the area.*** This discussion paper does not attempt to evaluate the effectiveness of these measures, although references are made to other works that do so, where available.

2.0 SELECTION OF ECOLOGICALLY SIGNIFICANT AREAS

2.1 Defining Ecologically Significant Areas

For the purposes of this report, an ecologically significant area is one that is deemed to have valued ecological attributes. The definition of ecologically significant used in this report is adapted from the definition used in the Significant Habitats Atlantic Coast Initiative (Schaefer *et al.* in press):

> Ecologically significant areas are those which have valued ecological attributes. Valued ecological attributes contribute to the functioning and sustainability of the ecosystem, the maintenance and conservation of genetic, species, population and/or habitat diversity, and/or other similar vital ecological functions. *These attributes are present to a higher degree than most/all other areas within the region* [emphasis added].

These attributes may be valued for their use by humans (both direct and indirect) or for other reasons. For example, areas important for the reproduction of fishery resources will be valued for their direct utility to people. Other areas may be valued for their existence or bequest value. Existence value has been defined as "the value that people derive from the knowledge that something exists, even if they never plan to use it" and bequest value is "derived from the desire to pass on values to future generations" (Dixon and Pagiola 1998: 3-4).

The definition and the concept of what is valued are elaborated in the criteria and indicators used to select ecologically significant areas. The criteria and indicators translate the concept of

"valued ecological attributes" into practical manifestations of what is valued. As desirable ecological attributes have been discussed in detail in the marine conservation literature, this paper has drawn extensively from that literature in selecting criteria for selecting ecologically significant areas. Again, it is emphasized that even though much of the literature on marine conservation pertains to MPAs, it does not mean that the areas profiled later in this document should automatically be considered potential MPAs.

2.2 Criteria for Ecological Significance

Many articles and reports on marine protected areas (MPAs) have discussed the process of selecting MPAs and the criteria that should be applied (see e.g., Kelleher and Kenchington 1992, Salm and Price 1995, Brody 1998, National Research Council 2001, Roberts *et al.* 2003a, Roberts *et al.* 2003b). The criteria for selecting marine protected areas in the literature generally include criteria related to ecological attributes. In selecting marine protected areas, both ecological criteria and other criteria must be considered, such as social criteria, economic criteria and more pragmatic criteria related to the feasibility of the area as an MPA. Consideration of non-ecological criteria is critical for marine protected area and integrated management planning but these criteria are not discussed in this paper.

Nilsson (1998) compared the criteria for selecting marine protected areas used in four previous publications. He found that many of the criteria listed were very similar and could be grouped together under several categories: naturalness, ecological or biogeographical value, and representativeness. Other authors have also noted the similarity of the criteria used by different selection systems (see e.g., Gregory and Brown 1999). These criteria are generally related to:

- the naturalness of the area,
- the importance of its productive processes, and
- the various indicators of its biogeographic value (such as species richness, use as a reproductive area, rare or unusual habitats, and the presence of rare or endangered species).

Many authors have discussed the rationale behind using these criteria and the reader is referred to those works (see e.g., Salm and Price 1995, Agardy 1997, Nilsson 1998, Brody 1998, Levings and Jamieson 1999, National Research Council 2001, Roberts *et al.* 2003a). It should be noted that many of the criteria found in the MPA literature are similar to the criteria listed under the *Oceans Act* for the designation of marine protected areas (Section 2.3).

Literature related to the conservation of fisheries resources tends to take a narrow approach to ecological significance, focussing on the enhancement of commercial stocks. For example, Gregory and Brown (1999) reviewed MPA selection criteria to find those criteria most relevant to a system of fisheries reserves. Those criteria were:

1. Protection of reproductives
2. Critical habitat carrying capacity and potential rate of increase
3. Recruitment export
4. Spillover
5. Genetic diversity
6. Terrestrial effects

7. Suitability for monitoring of non-fisheries impacts.

From the review of the literature, criteria were selected for the selection of areas of ecological significance on the Scotian Shelf and Slope. The focus was on criteria for ecological significance for a range of marine species and not simply criteria for the enhancement of fisheries resources. The criteria selected generally summarize those listed in the literature as ecological criteria for selecting MPA sites. For this report, the criteria were divided into two classes: selection or first-order criteria that could be used to make a first selection of areas, and weighting/ranking or second-order criteria that could be used to further distinguish between areas identified under first-order criteria. The first-order criteria used here are:

- biological productivity
- biodiversity (species and genetic diversity):
- reproductive areas
- bottleneck areas (non-reproductive)[1]
- habitat for endangered/threatened species
- rare/unique habitats and habitat for rare species
- naturalness[2]

Second-order criteria are as follows:

- dependency/survival
- fragility/sensitivity
- significance (Scotian Shelf and Slope/Northwest Atlantic/world)

Criteria can be further broken down into indicators. This is a similar process to setting objectives for ecosystem-based management, then "unpacking" the objectives into components and indicators. Indicators for the criteria listed above are found in Table 1. The indicators were drawn from those suggested in the literature (see e.g., National Research Council 2001, Jamieson and O'Boyle 2001, Roberts et al. 2003a, Roberts et al. 2003b).

Two other criteria are often mentioned in the literature: integrity (degree to which the area is a functional unit) and representativeness (degree to which the area is representative of a biogeographic area). Those two criteria have not been used here but would be appropriate to use in designing a system of complementary marine protected areas in a management region. They should also be considered in setting management boundaries.

---

[1] The term "bottleneck area" caused some confusion in reviewers of an earlier draft of this paper. It is used differently in other fields. It is used here because it addresses a concept which would not otherwise be considered. Roberts (2000) uses the term "migration bottleneck" to describe the areas where highly migratory species become concentrated at certain times of year. For this paper, "bottleneck areas" have been considered for both highly migratory species and for otherwise widespread species that are concentrated in some areas in particular times of year. It is listed separately from reproductive areas, which may or may not also be bottleneck areas. For example, the Cabot Strait represents a bottleneck in the migration route of blue whales, while the mudflats in the upper Bay of Fundy are a bottleneck area for migratory shorebirds.

[2] Naturalness could be used as a first- or second-order criteria and some reviewers of an earlier draft suggested that it was more appropriate to use as a second-order criteria. However, others have commented that it is critical to identify areas that are more natural (i.e., less disturbed by humans).

Table 1. Criteria for ecological significance and related indicators

Criteria for Ecological Significance	Indicators for the Scotian Shelf and Slope
Selection Criteria (First-Order Criteria)	
Biological productivity	• high surface chlorophyll concentrations • high integrated chlorophyll concentrations • high abundance of zooplankton • areas of high net export of productivity • areas of high levels of deposition of organic matter • in some cases, high abundance of other species may be an indicator
Biodiversity (species and genetic diversity)	• high diversity of species - high values for indices of species richness • populations distinct from other areas • diversity of habitat within a small area (habitat heterogeneity)
Reproductive areas	• breeding areas/spawning areas/nesting areas • areas with concentrations of eggs/larvae • areas with concentrations of juveniles/young
Non-reproductive bottleneck areas	• areas where particular species or groups of species are concentrated at certain times of the year, for example, some overwintering areas and portions of some migration routes
Habitat for endangered/threatened species	• concentrations of endangered/threatened species (as defined by COSEWIC) observed in the area • regular use of the area by endangered/threatened species • where there is little information, observations of endangered/threatened species in the area
Rare/unique habitats and habitat for rare species (not including species listed by COSEWIC as endangered/threatened)	• habitats found in only a few locations or nowhere else on the Scotian Shelf and Slope* • unique geological features and their related oceanographic features • habitats used by species that have limited occurrence or ranges (note that these may often be species found in rare/unique habitats)
Naturalness**	• areas that have been little disturbed by humans, e.g., no aggregate extraction or dredging, little shipping, petroleum or fishing activities • areas that are a refuge from human activity because their physical characteristics make them difficult to access • areas where levels of contaminants in the water column and in the sediments are low
Weighting/Ranking Criteria (Second-Order Criteria)	
Dependency/survival	• the area is critical to a species/population at some stage of its life cycle and there are few/no other areas on the shelf that can play the same role
Fragility/sensitivity	• the characteristics of the area make it particularly sensitive to human activities, more so than most other areas of the shelf, for example: - slow recovery time of habitat after disturbance - slow recovery time of species if disturbed in the area - oceanographic processes in area could lead to accumulation of contaminants - species found in the area are more sensitive to human-caused disturbance than species found in other areas
Significance (Scotian Shelf and Slope/Northwest Atlantic/world)	• the processes that occur there are important to the whole Scotian Shelf and Slope/Northwest Atlantic/world. • the characteristics/features that are ecologically significant (from above list) are significant to the whole Scotian Shelf and Slope/Northwest Atlantic/world

*Because of relatively little information, this may be habitats *known* from only a few locations on the Scotian Shelf (i.e., they may be more widespread than is currently known).

** This criterion could also be used as ranking/weighting (second-order) criterion.

Representative and "hotspot" approaches

Some of the literature favours a representative approach in selecting MPAs. Using a representative approach requires that all available information for a region be gathered. Geographical information systems (GIS) or other similar tools are used to overlay the information. From that, different habitats or seascapes would be identified (see e.g., Roff *et al.* 2003). Generally, this approach picks a target proportion of each habitat for protection, for example, 20 percent (see e.g., Beck and Odaya 2001). MPAs are then selected that represent the target proportion of each habitat area. Advocates of the representative approach consider that protecting a proportion of each habitat area is a good proxy for protecting many desired features. It may also be helpful in protecting biodiversity.

Efforts have been made to gather all available information and develop a classification framework for the Scotian Shelf (Day and Roff 2000, Kostylev 2002, Roff et al. 2003). These will lead to a better understanding of the Scotian Shelf and could be used to develop a representative system of protected areas.

However, the representative approach is not used nor addressed here. For that reason, this discussion paper does not address the different possible ways of classifying the marine environment. Instead, the approach taken is that some areas are more important than others, at least for some species or some processes. There has been criticism of this approach, sometimes called a "hotspot" approach.[3] Ray and McCormick-Ray (1995) called this method a "species-oriented concept." In an article advocating a representative process in selecting areas for conservation, they suggest that a critical habitats/species-oriented approach implies that some environments are void of life, when really it is our knowledge of the areas that is lacking.

The representative approach is not addressed here because existing management tools and measures tend to favour protecting areas with distinct and valued ecological features (see *Oceans Act* discussion below). As well, there appears to be ecological value in protecting the features of these areas (see e.g., Roberts *et al.* 2002 and Worm *et al.* 2003. For somewhat different findings see Turpie *et al.* 1999). One of the criticisms of the "hotspot approach" is that it tends to select areas important for charismatic species which may occupy distinctive habitats (see e.g., Roff and Evans 2002). However, many of the potentially ecologically significant areas profiled later in this document tend to be important for many different species. Roff and Evans (2002) discuss what they call a "distinctive habitats" approach that has similarities to the approach found in this report and also discuss the use of both distinctive and representative approaches in marine conservation.[4]

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[3] Note that the "hotspot" approach tends to be narrowly defined and species-focussed in the literature; however, the criteria and indicators for ecologically significant areas used here are somewhat broader.

[4] While their approach has similarities, it is not the same as the approach found here. They suggest that a conservation strategy that addresses only distinctive habitats where flagship species are found will leave the "ordinary" parts of the biosphere at risk. If distinctive habitats and flagship species are narrowly defined, the risk of leaving out the "ordinary" may be higher. However, it may be found that a series of ecologically valued sites (broadly defined) also represent many different habitats. As the goal for this report was to promote discussion on integrated management and identifying sites that may need special management measures, how well these sites fit together as a representative system has not been evaluated.

2.3 Ecologically Significant Areas and the *Oceans Act*

The *Oceans Act* recognizes that certain areas of the ocean have features that are distinct from other areas. For example, the Act states that DFO may establish an MPA for any one of the following reasons (section 35.2):

- the conservation and protection of commercial and non-commercial fishery resources, including marine mammals, and their habitats;
- the conservation and protection of endangered or threatened marine species, and their habitats;
- the conservation and protection of unique habitats;
- the conservation and protection of marine areas of high biodiversity or biological productivity; and
- the conservation and protection of any other marine resource or habitat as is necessary to fulfil the mandate of the Minister (of Fisheries and Oceans).

Four of the five reasons explicitly target habitats or areas that have some special ecological features: areas important for the conservation and protection of fishery resources, areas that are habitat for endangered or threatened species, areas with unique habitats, and areas with high biodiversity or biological productivity.

It is important to recognize that the *Oceans Act* does not explicitly include representativeness as a criterion for the establishment of marine protected areas, although the value of representativeness as a criterion in establishing a network of MPAs is recognized in many scientific papers. More information on DFO's MPA program can be found in the *Marine Protected Areas Policy* (DFO 1999a) and the *National Framework for Establishing and Managing Marine Protected Areas* (DFO 1999b).

2.4 Applying the Criteria

The study area used in this paper is the same as used in Breeze *et al.* (2002) (Figure 1) and does not include areas immediately adjacent to the coast (within approximately 12 nautical miles), nor Georges Bank and the Bay of Fundy. Nearly every area of the Scotian Shelf and Slope could meet one or more of the criteria in some way. However, the purpose of this exercise was to select outstanding areas: areas for which there was scientific evidence that the valued attributes are present to a greater degree than other areas within the study area. These areas were selected using the process described below.

Assessing Sub-areas of the Shelf and Slope

The Scotian Shelf and Slope was divided into sub-areas based on traditional divisions used in the literature, as well as some groupings done for convenience (i.e., large banks, channels and basins were listed separately, some small bank and saddle areas were grouped together).[5] Although these divisions are generally based on bottom habitat features, indicators for the criteria include both benthic and pelagic features. Thus, *both benthic and pelagic features of each area were considered, where possible*. For example, areas may be important because of

[5] This division into areas was done for convenience of evaluating the areas and should not be considered a classification system for the Scotian Shelf.

the high diversity and abundance of larval fish, many of which are pelagic. Other areas may be important because of rare or unique populations of benthic species. The important benthic and pelagic features may not overlap entirely or may not be present at the same time of year.

Each sub-area was listed next to the first-order criteria. Each sub-area was examined in relation to the indicators for the first-order criteria (listed in Table 1). These indicators were based on those used in the literature and further discussion may deem some indicators more appropriate for the Scotian Shelf and others less so. Sub-areas that potentially met a higher value for a criterion than other parts of the Scotian Shelf were indicated (Table 2).

Assessments of the areas were based on information from the literature. If the area ranked high according to the indicators for one or more of the first-order criteria, it was given a descriptive profile (found later in this document). Assessments were based on the available information (see references in Breeze *et al.* 2002 and Appendix 1 of OCMD 2003). Additional information could change these assessments.

It should be noted that for some of the potentially significant areas, the evidence supporting their ecological significance may be found in only one paper or report. In some cases, this evidence is not supported by conclusions in other documents. However, it was considered important to profile areas that have been considered potentially ecologically significant by other authors, even in the face of contradictory evidence. By describing these areas it will encourage discussion of their potential importance relative to other areas with similar features.

Figure 1. The Scotian Shelf and Slope, with study area shaded.

As an example of how each sub-area was assessed against the criteria, we will take the sub-area of Roseway Basin and the criterion of habitat for endangered/threatened species. Indicators for that criterion are concentrations of endangered/threatened species observed in the area, regular use of the area by endangered/threatened species, and where there is little information, observations of endangered/threatened species in the area. The North Atlantic right whale is an endangered species found on the Scotian Shelf in the summer. Right whales have been sighted in many areas of the shelf, but they have been sighted more often and in greater numbers in Roseway Basin and in some areas of the central shelf. There are scientific reports supporting their regular use of Roseway Basin. For those reasons, Roseway Basin meets the criterion of habitat for endangered/threatened species to a greater degree than most other areas of the Scotian Shelf.

Information available

While assessing each sub-area, it became obvious that there was a great deal of information for some parts of the shelf and very little for others. It is important to recognize the different levels of information in interpreting the results for each sub-area. To give a rough portrayal of the differing amounts of information, the author categorized the sub-areas according to the level of information available relative to other areas of the shelf and slope:

> ***Good:*** There is information particular to the area from research trawl surveys for fish, hydrographic data, studies of the benthic environment and regional surficial geology reports. There is some information on whale distribution, and there is information on some other characteristics of the area, such as, multibeam data, information on patterns of sedimentation, or information on larval fish. Examples of areas for which there is good information: Browns Bank and Western Bank.
>
> ***Fair:*** There is information particular to the area from research trawl surveys, hydrographic data and surficial geology reports. There is some information on other characteristics of the area but less than areas in the "good" category. Examples of areas for which information is fair: Emerald Basin and Middle Bank.
>
> ***Poor:*** There is general information for the area and there may be one or two studies on some aspect of the environment (e.g., geology), but it is generally not well-studied. Examples of areas for which information is poor: Scotian Slope and Misaine Bank.
>
> ***Fair-Good:*** There is less information than the examples given for "good" but more than the examples given for "fair". Example: The Gully.
>
> ***Poor-Fair:*** There is less information than the examples given for "fair" but more than those for "poor". Example: Stone Fence.

The evaluation of the relative level of information is meant to show that little is known about some areas. Further research may show aspects of their ecology that would change their evaluation against some of the criteria for ecological significance. It may also change the evaluation of other areas, since the areas were assessed for potentially high values relative to each other. For example, Western Bank has been found to have a high diversity of larval fish compared with other areas of the Scotian Shelf (Shackell and Frank 2000), an indicator for the criterion of biodiversity. If future research found that Misaine Bank had a much higher diversity

of larval fish than Western Bank, Western Bank would then be considered less important under the criterion of biodiversity (if solely the indicator of species richness of larval fish was considered).

In fields of study for where there is extensive information, only areas known to meet a criterion to a higher degree than other areas were indicated. However, for fields where there was little information, areas potentially important were identified. For example, spawning areas for haddock on the Scotian Shelf are fairly well known. For that reason, not all spawning areas for haddock are identified in this report. Instead, the focus is on the areas that have been identified in the literature as most important for haddock spawning. On the other hand, areas important for marine mammals and areas *potentially* important for marine mammals were both identified (e.g., if there is little scientific information on their distribution, observations of marine mammals in a particular sub-area assume greater importance). There has been little research and analysis of the biogeography of many marine mammals of the Scotian Shelf and Slope. Since many of these animals are listed as species at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), it was considered important to identify areas that are potentially important to help direct future research.

Table 2. Areas of the Scotian Shelf and Criteria for Ecological Significance

Area	Relative level of information for this geographic area (Good, Fair, Poor)[6]	Criteria	Potential high value? (Y/N/?[7])
Sydney Bight	Good	biological productivity	Y
		biodiversity	Y
		reproductive areas	Y
		non-reproductive bottleneck areas	Y
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Laurentian Channel (Cabot Strait)	Good	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	Y
		habitat for endangered/threatened species	Y
		rare/unique habitats and species	N
		naturalness	N
Laurentian Channel (deep waters of Stone Fence)	Poor-Fair	biological productivity	N
		biodiversity	Y
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	Y
		naturalness	P
Laurentian Channel (other than Cabot Strait & Stone Fence)	Poor-Fair	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	P

[6] See text for definition of good/fair/poor.
[7] Y=Yes, N=No, P=probably. For the purposes of this exercise, N is also equivalent to unknown.

Area	Relative level of information for this geographic area (Good, Fair, Poor)[6]	Criteria	Potential high value? (Y/N/?[7])
Misaine Bank	Poor	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Shrimp Holes near Canso and Misaine Banks	Poor-Fair	biological productivity	Y
		biodiversity	N
		reproductive areas	P
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Canso Bank	Poor	biological productivity	N
		biodiversity	P
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Banquereau	Fair-Good	biological productivity	Y
		biodiversity	N
		reproductive areas	Y
		non-reproductive bottleneck areas	Y
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
The Gully (including the Trough)	Fair-Good	biological productivity	Y
		biodiversity	Y
		reproductive areas	N
		non-reproductive bottleneck areas	Y
		habitat for endangered/threatened species	Y
		rare/unique habitats and species	Y
		naturalness	P
Shortland and Haldimand Canyons	Poor	biological productivity	N
		biodiversity	Y
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	Y
		rare/unique habitats and species	P
		naturalness	P
Logan Canyon	Poor	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	P

Area	Relative level of information for this geographic area (Good, Fair, Poor)[6]	Criteria	Potential high value? (Y/N/?[7])
Dawson and Vernil Canyons	Poor	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	P
"No-name" Canyon (small submarine canyon south of Emerald Bank)	Poor	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	P
Middle Bank	Fair	biological productivity	Y
		biodiversity	Y
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
French Bank	Poor	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Mid-shelf between Emerald Basin and French Bank (including The Patch)	Poor	biological productivity	N
		biodiversity	Y
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	Y
		naturalness	N
Sable Island	Good	biological productivity	N
		biodiversity	Y
		reproductive areas	Y
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	Y
		rare/unique habitats and species	Y
		naturalness	N
Sable Island Bank (other than Sable Island)	Good	biological productivity	N
		biodiversity	Y
		reproductive areas	Y
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N

Area	Relative level of information for this geographic area (Good, Fair, Poor)[6]	Criteria	Potential high value? (Y/N/?[7])
Western Bank	Good	biological productivity	Y
		biodiversity	Y
		reproductive areas	Y
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Western Gully	Fair	biological productivity	P
		biodiversity	N
		reproductive areas	Y
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	Y
		rare/unique habitats and species	N
		naturalness	N
Emerald Bank	Fair-Good	biological productivity	N
		biodiversity	N
		reproductive areas	Y
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Emerald Basin	Fair	biological productivity	Y
		biodiversity	N
		reproductive areas	Y
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	Y
		rare/unique habitats and species	N
		naturalness	N
Outer shelf between Emerald Bank and LaHave Bank ("Scotian Gulf")	Fair	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Sambro Bank	Poor	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
LaHave Basin	Fair	biological productivity	N
		biodiversity	N
		reproductive areas	P
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	P
		rare/unique habitats and species	N
		naturalness	N

Area	Relative level of information for this geographic area (Good, Fair, Poor)[6]	Criteria	Potential high value? (Y/N/?[7])
LaHave Bank	Poor	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	Y
Saddle between Baccaro and LaHave Banks	Poor	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Baccaro Bank	Poor-Fair	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Browns Bank	Good	biological productivity	Y
		biodiversity	N
		reproductive areas	Y
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Northeast Channel	Good	biological productivity	N
		biodiversity	P
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	Y
		naturalness	N
Roseway Basin	Good	biological productivity	Y
		biodiversity	N
		reproductive areas	Y
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	Y
		rare/unique habitats and species	N
		naturalness	N
Roseway Bank	Poor	biological productivity	N
		biodiversity	N
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N

Area	Relative level of information for this geographic area (Good, Fair, Poor)[6]	Criteria	Potential high value? (Y/N/?[7])
German Bank and Area	Fair-Good	biological productivity	N
		biodiversity	N
		reproductive areas	Y
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	N
		naturalness	N
Scotian Slope (general)	Poor	biological productivity	N
		biodiversity	P
		reproductive areas	N
		non-reproductive bottleneck areas	P
		habitat for endangered/threatened species	N
		rare/unique habitats and species	P
		naturalness	P
Laurentian Fan	Poor	biological productivity	N
		biodiversity	Y
		reproductive areas	N
		non-reproductive bottleneck areas	N
		habitat for endangered/threatened species	N
		rare/unique habitats and species	Y
		naturalness	P

Applying the Criterion of "Naturalness"

The exception to this method of applying the criteria was the method of selecting areas with high values for "naturalness." There was little information available in the literature on the naturalness of different areas of the Scotian Shelf, although some areas of the slope were considered "probably" natural because of great depths and inaccessibility. One area of the shelf (LaHave Bank) was identified in the literature and profiled. However, it seemed possible that other areas of the shelf had higher values for naturalness. Lack of human disturbance by fishing activity is one of the indicators given in the literature for naturalness, so fishing records for the Scotian Shelf were examined to find areas that were little fished over the last ten years. Those areas are described together in one profile. Records of other human activity on the Scotian Shelf could also be examined to find areas with less activity and potentially higher values for naturalness, for example, areas without shipping routes, petroleum exploration, submarine cables, etc.

Are the Criteria Appropriate?

As Nilsson (1998) pointed out, it is important that the criteria and indicators used accurately reflect the objective or objectives behind selecting the areas (in this case, selecting sites with valued ecological attributes) and that they are relevant for the environment in which they are used. They should also be readily understandable to those who are applying the criteria and indicators. Readers are encouraged to review the criteria and indicators used here and reflect on their appropriateness for the Scotian Shelf and Slope. As well, there are likely other areas that potentially have high values relative to the rest of the Scotian Shelf and Slope. Readers are encouraged to consider what other areas of the shelf and slope that could potentially meet the criteria described here.

2.5 Weighting the Criteria

A weighting system would assign values for each criterion for every sub-area. A weighting or ranking scheme is not used here; however, one would be useful in further evaluation of these areas. It should be noted that there are problems with weighting schemes if the amount of information for each area is not equal. For example, weighting schemes may undervalue unique habitats for which little is known and overvalue habitats for which there is much information. Nilsson (1998) discussed the selection of high priority areas for assessment in Sweden. He noted that areas selected in Sweden as high priority were also the areas for which "quite a lot is known, which therefore permitted detailed analysis" (p. 44).

Ranking/weighting systems can determine which areas are the most important or most in need of special management measures. Levings and Jamieson (1999) suggest using a list of considerations under each criterion to develop a score for each area. However, in selecting areas requiring special management measures, some criteria and related indicators should be given more consideration than others. For example, Roberts *et al.* (2003b) suggests that habitat heterogeneity may be a better indicator than species richness as a measure of desirability for an MPA, if there is incomplete information on species richness. In deciding which areas to protect, areas with species with restricted ranges should be given more weight than areas with species that are abundant and widely distributed (see Roberts *et al.* 2003b).

Various weighting methods have been developed to select priority areas for conservation. Two common approaches are mathematical selection models, using software such as SITES and MARXAN, and expert opinion approaches that use relative scoring or ranking. Roberts *et al.* (2003b) briefly describe the positive and negative features of these selection approaches. Possingham *et al.* (2000) described how mathematical selection models could be used in identifying representative reserve networks. Laffoley *et al.* (1997) described an expert opinion approach that was taken at a NOAA workshop (a process termed a "Delphic" exercise). This structured expert opinion exercise aimed to reach consensus on important features.

The two approaches are not as widely divergent as they may appear. The conservation objectives and the delineation of geographic units must be specified for mathematical selection programmes to work (see e.g., Beck and Odaya 2001) and should be specified for expert opinion processes to work well (see e.g., Laffoley *et al.* 1997, Roberts *et al.* 2003). The mathematical site-selection algorithms may also give more than one "right" answer. Leslie *et al.* (2003) used SPEXAN/SITES software and found that there were many ways to select a combination of sites to meet particular goals. Some planners have used a combination of the expert opinion and mathematical selection model approaches (see e.g., Beck and Odaya 2001, Airamé *et al.* 2003).

This discussion paper is primarily concerned with ecological criteria for selecting important areas. However, in developing management plans appropriate to each area, other criteria should also be considered. As well as ecological criteria, economic, social and pragmatic considerations should be weighted and added to any full ranking system.

2.6 Other Efforts to Select Important Marine Areas on the Scotian Shelf and Slope

An exercise to select nationally significant marine conservation areas in the Scotian Shelf region was undertaken by P. Lane and Associates in 1992 for Parks Canada. They described the features of the Scotian Shelf, including coastal areas, and then identified distinctive features or characteristics of each area. Each feature was given a rating by the researchers according to three criteria: occurrence, significance and importance. Based on this rating, the researchers identified what they considered outstanding key features of the Scotian Shelf that corresponded to particular geographic areas. Each feature was rated broadly according to geological, oceanographic, biological and cultural/historical themes. From that, the three top areas were rated in more detail. These areas were suggested as preliminary Natural Areas of Canadian Significance (NACS). Parts of two of these areas are included in the profiles found later in this document; their third area was along the coast and is does not fall within the study area used here.

In 1999, the Marine Conservation Biology Institute (MCBI) held a workshop during which 21 scientists from Canada and the United States selected priority areas for conservation in the Gulf of Maine and Georges Bank, including parts of the Scotian Shelf off southwest Nova Scotia. More than thirty areas were identified; some of the areas were very large. This workshop took an expert opinion approach to the selection of areas but was somewhat informal and did not rank priority areas. Parts of all the areas selected at the MCBI workshop are profiled here.

The World Wildlife Fund is taking a representative approach to selecting areas for marine conservation. They released a report showing a framework for classifying habitats, using the Scotian Shelf as an example (Day and Roff 2000). The habitat classification was further refined and its authors suggest this could form the basis of further analyses, including management of marine resources (Roff *et al.* 2003).

3.0 PROFILES OF AREAS OF KNOWN OR POTENTIAL ECOLOGICAL SIGNIFICANCE

Profiles of areas with potentially higher values for the first-order criteria are described in this section (Figure 2). The profiles are short descriptions of key features of the area in a fact sheet style. Some of the sub-areas have been grouped together because they share the same important feature and there are management measures that have been applied to the entire area (e.g., Western-Emerald Bank complex). For other sub-areas, only a portion of the area was known to have the potentially ecologically significant features. Only that smaller area is described here. The profiles are in no particular order, as no weighting scheme was applied.

Each area is discussed under several headings. *Location* describes the geographic location of the ecologically important area. Area boundaries were not precisely defined, although some existing management boundaries were shown. *Current status* describes any management designations for the area (e.g., whale sanctuary, migratory bird sanctuary, fisheries closures, etc.). *Human Activities* provides a list of types of activities that currently take place in the area, e.g. fishing, petroleum. *Criteria* lists the first-order criteria found in Table 2 that seem to be present to a greater degree in that area, and the second-order criteria that are also applicable. *Importance* describes the criteria in relation to that area in particular. *Remarks* describe the features of the area as related to its importance. It may also include suggestions for research in relation to the importance of the area. For a few of the areas, there is contradictory evidence as to their significance compared with other areas of the shelf. These areas might not rank very highly if thorough evaluations of each area were carried out.

Other than a few submarine canyons, only one area of the slope is described. This is due to a lack of information about the slope and rise, not due to a lack of ecologically significant areas. Although little is known about the slope and rise, it is an area of rapidly expanding hydrocarbon exploration and development activities, as well as fisheries. The increasing activities on the Scotian Slope makes further research on the ecology of the slope important for ocean planning and integrated management initiatives.

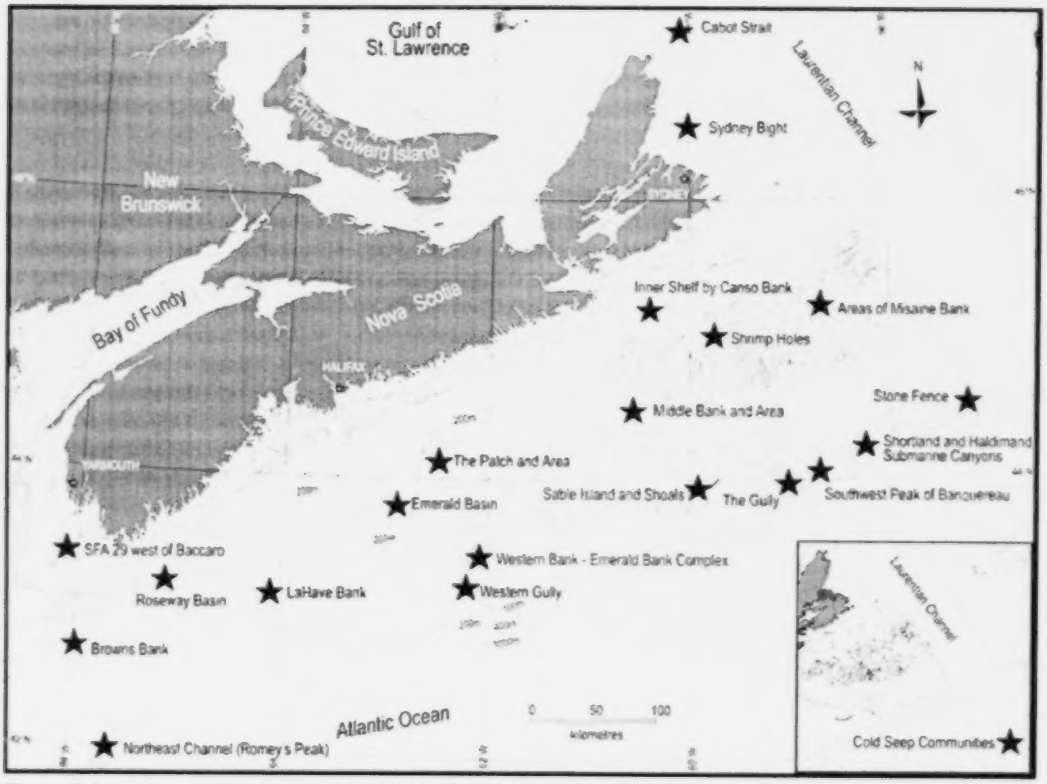


Figure 2. Location map of areas profiled. Note that the star indicates the general location of the area. The actual area may be larger or smaller than indicated by the star.

3.1 Sydney Bight

Location: East of Cape Breton and west of the Laurentian Channel (Figure 3).

Figure 3. Sydney Bight.

Current Status: No directed fishery for cod and haddock in 4Vn (a moratorium on the winter fishery for overwintering Gulf of St. Lawrence cod was announced in April 2003). Hertford Island (one of the Bird Islands) is a Nova Scotia Bird Society Sanctuary. The Bird Islands have been identified as Important Bird Areas by Bird Life International, as has Ingonish Island.

Human Activities: fishing, shipping, MARLANT exercise area Q1. Petroleum exploration is planned.

Criteria (1): biological productivity, biodiversity, reproductive areas, non-reproductive bottleneck areas
(2): dependency/survival, significance (Scotian Shelf and Gulf of St. Lawrence)

Importance:

- Abundant zooplankton, including larval stages of fish and benthic invertebrates.
- Fish from the Gulf of St. Lawrence overwinter in the deeper parts of Sydney Bight and the adjacent Laurentian Channel.

- Sydney Bight is a spawning and nursery area for cod and other fish and several species of commercial invertebrates.
- It has indications of high species richness of marine fish.
- Islands within Sydney Bight (e.g., Bird Islands, Ingonish Island) are important bird nesting areas.

Remarks: Sydney Bight is not described in detail in this report. Schaefer *et al.* (in press) and DFO (2001) have described the area in detail. As well, Schaefer *et al.* (in press) have identified ecologically significant areas within Sydney Bight. Locke (2002) has described the ichthyoplankton and invertebrate zooplankton of the area. Shackell and Frank (2003) identified Sydney Bight as an area of high marine fish diversity.

There was some public opposition when the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) granted three petroleum exploration leases in the Sydney Bight-Gulf of St. Lawrence region in 1998 and 1999. Subsequently, the federal and provincial governments requested the CNSOPB to conduct a public review of the effects of hydrocarbon exploration and drilling in offshore Cape Breton. After the review, the CNSOPB established an ad hoc working group to review existing science for the area and make recommendations on petroleum activities for the region. No exploration activity was permitted in the lease areas during the public review and working group period. The ad hoc working group report was submitted in February 2003. The members of the group could not reach consensus on whether or not petroleum exploration and development should be permitted in the area, but did agree on some issues (Ad hoc 2003). Following the working group's report, the CNSOPB issued guidelines that set out conditions for seismic exploration in the area (CNSOPB 2003).

References (this section):

Ad hoc Working Group. 2003. Report to the Canada-Nova Scotia Offshore Petroleum Board. February 2003. Internet document. <http://www.cnsopb.ns.ca/Environment/ad hoc.html> Accessed 11 August 2003.

CNSOPB (Canada-Nova Scotia Offshore Petroleum Board). 2003. Board Acts on Ad Hoc Working Group Report. New release. Issued 6 March 2003. Internet document. <http://www.cnsopb.ns.ca/Whatsnew/whatsnew.html> Accessed 11 August 2003.

DFO (Fisheries and Oceans Canada). 2001. Description of the Southern Gulf of St. Lawrence and Sydney Bight Marine Ecosystems in Relation to Oil and Gas Exploration. DFO Maritime Provinces Regional Habitat Status Report 2001/01.

Locke, A. 2002. The ichthyoplankton and invertebrate zooplankton of the coastal waters of Cape Breton Island: a review. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2606.

Schaefer, H.L., D. McCullough, S.K. Johnston and D.R. Duggan. In press. Significant Habitats Atlantic Coast Initiative (SHACI). Unit 11 – Sydney Bight. Canadian Manuscript Report of Fisheries and Aquatic Sciences.

Shackell, N.L. and K.T. Frank. 2003. Marine Fish Diversity on the Scotian Shelf, Canada. Aquatic Conservation: Marine and Freshwater Ecosystems 13: 305-321.

3.2 Cabot Strait, Laurentian Channel

Location: Off northeastern Cape Breton (Figure 4)

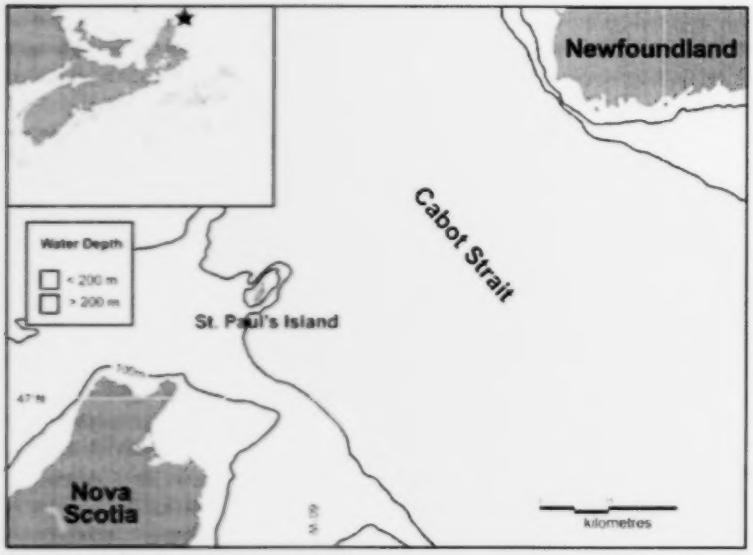


Figure 4. Cabot Strait, Laurentian Channel.

Current Status: No management restrictions particular to the area. No directed fishery for cod and haddock in 4Vn (a moratorium on the winter fishery for overwintering Gulf of St. Lawrence cod (4TVn) was announced in April 2003).

Human Activities: shipping, fishing, submarine cables, MARLANT exercise area Q1, research activities.

Criteria (1): biodiversity, bottleneck area, habitat for endangered/threatened species, ***(2):*** significance (some features Scotian Shelf and Slope, some Northwest Atlantic)

Importance:

- Migration route for many species of fish and invertebrates.
- Migration route for whales and seals.
- Slope of Laurentian Channel in this area is an overwintering area for many species of groundfish.

Remarks: Kenchington (2001) and DFO (2001) highlighted the importance of the Laurentian Channel as a migration route, particularly for fish species that spend the summer in the Gulf of St. Lawrence and overwinter in the deep waters of the Channel and Sydney Bight. Groundfish are more concentrated in this area in the winter than they are during the summer. The southern Gulf of St. Lawrence cod stock overwinters along the eastern slope of the Laurentian Channel, with concentrations in some areas, for example, near St. Paul's Island (Campana *et al.* 1999). Cod are highly concentrated in the channel at depths between 250 and 450 metres where water

temperatures range from 4.9 to 5.3°C (Campana *et al.* 1999). Thorny skate, white hake and American plaice from the Gulf also overwinter in the Laurentian Channel, largely north of the Cabot Strait, within the Gulf, but also in the Cabot Strait area (see Clay 1991).

Fifteen species of whales are known to occur in or pass through Cabot Strait on their way to feeding grounds (DFO 2001). Whales can be found off eastern Cape Breton in the spring, summer and fall. Blue whales, humpback whales, fin whales, minke whales, long-finned pilot whales, white-sided dolphins and harbour porpoises are regularly observed in the area (DFO 2001).

An unknown but likely high percentage of the world's endangered blue whales pass through the Cabot Strait on their way to and from rich summer feeding grounds in the Gulf of St. Lawrence. Three hundred and eight individual whales have been photo-identified in the Gulf (Sears *et al.* 1987 cited in Waring *et al.* 2000) and there may only be a few hundred whales in the Northwest Atlantic population (Waring *et al.* 2001). Many of these whales likely pass through the Cabot Strait. Blue whales feed on high densities of krill.

Harp and hooded seals may occasionally transit the area from breeding grounds in the Gulf. Leatherback turtles have been observed in the area (see e.g., LTWG 2002).

Invertebrates also travel through the Cabot Strait to other parts of the Northwest Atlantic. In the spring, copepods are carried from the Gulf through the Cabot Strait and onto the Scotian Shelf. Other zooplankton (including larval lobsters) pass through the channel as well (see Harding et al. 1983, Locke 2002). Some snow crabs move from the southwestern Gulf of St. Lawrence to Sydney Bight through this area (see Biron *et al.* 2003).

After the public review of the potential effects of hydrocarbon exploration and drilling in offshore Cape Breton, the CNSOPB established an ad hoc working group to review existing science for the area and make recommendations. The members of the group could not reach consensus on whether or not petroleum exploration and development should be permitted in the area, but did agree on some issues (Ad hoc 2003). Following the working group's report, the CNSOPB issued guidelines that set out conditions for seismic exploration in the area (CNSOPB 2003).

The briefly re-opened 4TVn cod fishery was once again placed under a moratorium in April 2003, due to the poor status of the stock. This fishery targeted Gulf stocks that overwinter in the Laurentian Channel off Cape Breton.

References (this section):

Ad hoc Working Group. 2003. Report to the Canada-Nova Scotia Offshore Petroleum Board. February 2003. Internet document. <http://www.cnsopb.ns.ca/Environment/ad hoc.html> Accessed 11 August 2003.

Biron, M., L. Savoie, C. Sabean, E. Wade and M. Moriyasu. 2003. Assessment of the 2002 Snow crab (*Chionoecetes opilio*) fishery off eastern Nova Scotia (Areas 20 to 24). Canadian Science Advisory Secretariat Research Document 2003/012.

Campana, S.E., G.A. Chouinard, J.M. Hanson, and A. Fréchet. 1999. Mixing and migration of overwintering Atlantic cod (*Gadus morhua*) stocks near the mouth of the Gulf of St. Lawrence. Canadian Journal of Fisheries and Aquatic Sciences 56: 1873-1881.

Clay, D. 1991. Seasonal distribution of demersal fish (Osteichthyes) and skates (Chrondrichthyes) in the southeastern Gulf of St. Lawrence. In: J-C. Thernault, ed. The Gulf of St. Lawrence: Small ocean or big estuary? Canadian Special Publication of Fisheries and Aquatic Sciences 113.

CNSOPB (Canada-Nova Scotia Offshore Petroleum Board). 2002. Prohibition order remains for offshore Cape Breton. August 30, 2002. Internet document. <http://www.cnsopb.ns.ca/Whatsnew/whatsnew.html> Accessed 16 December 2002.

DFO (Fisheries and Oceans Canada). 2001. Description of the Southern Gulf of St. Lawrence and Sydney Bight Marine Ecosystems in Relation to Oil and Gas Exploration. DFO Maritime Provinces Regional Habitat Status Report 2001/01.

Harding, G.C., K.F. Drinkwater, and W.P. Vass. 1983. Factors influencing the size of American lobster (*Homarus americanus*) stocks along the Atlantic coast of Nova Scotia, Gulf of St. Lawrence, and Gulf of Maine: A new synthesis. Canadian Journal of Fisheries and Aquatic Sciences 40: 168-184.

Kenchington, T.J. 2001. Some environmental effects of petroleum activity offshore Unamaki. Prepared for the Unamaki Institute of Natural Resources and the Union of Nova Scotia Indians. Internet document. <http://www.cnsopb.ns.ca/Archives/Cape_Breton/cbindexa.html> Accessed 30 October 2002.

Locke, A. 2002. The ichthyoplankton and invertebrate zooplankton of the coastal waters of Cape Breton Island: a review. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2606.

LTWG (Leatherback Turtle Working Group). 2002. Tracking Sherman. Internet document. <http://www.seaturtle.ca> Accessed 10 October 2002.

Sears, R., F. Wenzel and J. M. Williamson. 1987. The blue whale: a catalog of individuals from the western North Atlantic (Gulf of St. Lawrence). Mingan Island Cetacean Study, St. Lambert, Quebec, Canada, 27 pp.

Waring, G.T., J.M. Quintal, and S.L. Swartz, eds. 2000. Marine Mammals Atlantic Stock Assessment Report. National Marine Fisheries Service. NOAA Technical Memorandum NMFS-NE-162.

Waring, G.T., J.M. Quintal, and S.L. Swartz, eds. 2001. U.S. Atlantic and Gulf of Mexico Marine Mammals Stock Assessments – 2001. National Marine Fisheries Service. NOAA Technical Memorandum NMFS-NE-168.

3.3 Stone Fence

Location: Slope of Laurentian Channel next to eastern Banquereau (Figure 5)

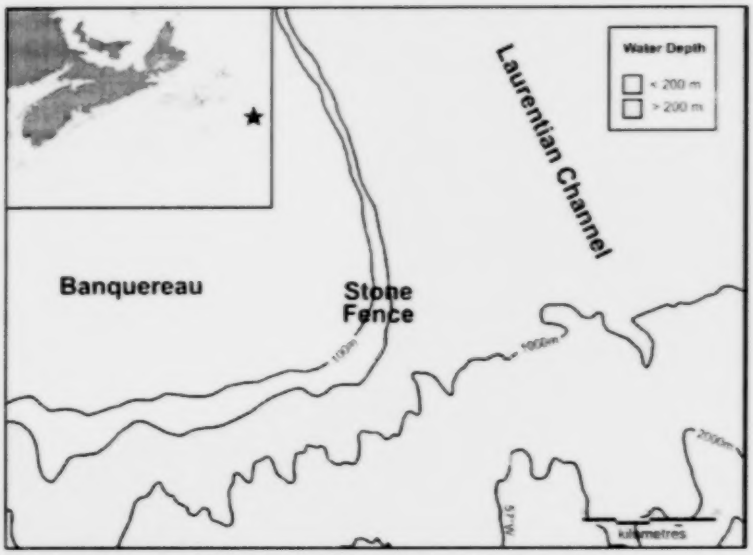


Figure 5. Stone Fence (slope at mouth of Laurentian Channel).

Current Status: No management restrictions particular to the area. No fisheries for cod and haddock (part of 4VsW closure).

Human Activities: fishing (particularly for halibut and redfish), petroleum exploration, shipping, research activities, MARLANT exercise area Q3.

Criteria (1): biodiversity, rare/unique habitat and habitat for rare species (perhaps other criteria as well, such as biological productivity and naturalness)
(2): fragility/sensitivity, significance (some features Scotian Shelf and Slope, some features Northwest Atlantic)

Importance:

- Identified as an area rich in deep sea corals by fishermen; fisheries observers have reported coral as bycatch from this area.
- DFO researchers observed *Lophelia pertusa*, a cold-water reef-building coral that has not been observed elsewhere in Atlantic Canadian waters (although there are reports and specimens from The Gully).
- Deep sea corals have a wide range but relatively patchy distribution on the Scotian Shelf.
- Other species are associated with coral species, resulting in rich communities.

- Corals can be broken off by fishing gear or other heavy objects and may be vulnerable to sedimentation.

- There are high redfish and halibut catches from the area.

- There are concentrations of humpback whales, at least in some years.

Remarks: In 1884, Captain J.W. Collins wrote that an area on the slope of Banquereau had the greatest abundance of corals on the Grand Banks. The highest concentrations were found at depths of 150 to 200 fathoms (274 to 366 metres) and perhaps deeper. He commented:

> This "spot," which is several miles in extent [...] is covered to such an extent with a coral growth that it seldom happens that trawl-lines set on it are all recovered. The fishermen have learned to avoid the place somewhat, and they have given it the name of "The Stone Fence." Stones of considerable size (as large as the fishing lines will lift) are not infrequently pulled up [...] (p. 237).

Fishermen have noted the area as abundant in deep sea corals in more recent times (Breeze *et al.* 1997, Gass 2002). Gass (2002) found the Stone Fence area to be a "hotspot" for deep sea corals in her study of the eastern Scotian Shelf and areas off Newfoundland and Labrador. She also found that fishermen had observed a decrease in the abundance of coral "trees" and the hard bottom habitat that corals prefer in the Stone Fence area. Some of this decrease likely occurred when trawlers first used the area heavily.

Scientific research in the Stone Fence area found a diversity of deep sea gorgonian corals in the area (MacIsaac *et al.* 2001). Research in 2002 found living fragments of the scleractinian coral *Lophelia pertusa*. This coral is related to the tropical reef-building corals. It is long-lived and slowly builds reefs that host many other animals (see Mortensen and Rapp 1998, Fossa and Mortensen 1998). The researchers expressed concern that the Stone Fence corals were being damaged by fishing gear (Mortensen quoted in Auld 2002). This coral has not been observed alive anywhere else in Atlantic Canada, although dead fragments of *Lophelia pertusa* have been collected by fishermen who report them from The Gully (Breeze *et al.* 1997, Gass 2002). The oceanographic features of the channel provide good conditions for coral communities, with currents regularly carrying zooplankton and organic particles past the filter feeders.

The Stone Fence and mouth of the Laurentian Channel is a major redfish fishing area. It is one of the most important areas for the redfish fishery on the eastern Scotian Shelf (Figure 6). The Stone Fence is also an important halibut fishing areas on the eastern Scotian Shelf (Figure 7). Both of these fish species appear to frequently occur in areas with deep sea corals because of similar habitat preferences but perhaps also because of the additional habitat complexity provided by the corals. Redfishes are commonly fished by bottom trawl on the Scotian Shelf, but can also be fished by mid-water trawl. They move towards the surface at night to feed on pelagic crustaceans and small fishes.

There has been little research on the distribution of whales on the eastern Scotian Shelf, other than the research in The Gully and a survey of the 1000-metre isobath of the slope. However, American researchers surveyed the Scotian Shelf for a couple of weeks in the summer of 2002 (Clapham and Wenzel 2002). During their survey, humpback whales were observed in greater numbers than other baleen whales on the eastern Scotian Shelf. They noted high concentrations of humpbacks in two areas of the eastern shelf. One of the areas was the Stone Fence. Other recent surveys by American researchers have suggested that the Scotian Shelf is a more important area for humpback whales than previously known (Waring *et al.* 2002). It seems to represent an important feeding area in its own right, as opposed to an

extension of the Gulf of Maine feeding grounds, or a transit area for animals feeding off Newfoundland (see Waring *et al.* 2002).

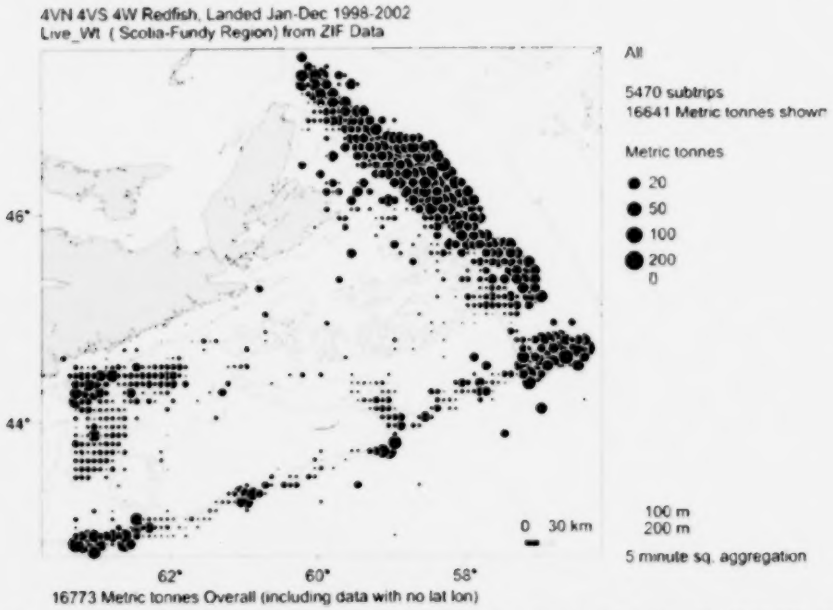


Figure 6. Location and landings from redfish fisheries, eastern Scotian Shelf (4VW), 1998-2002. Landings aggregated by 5-minute squares.

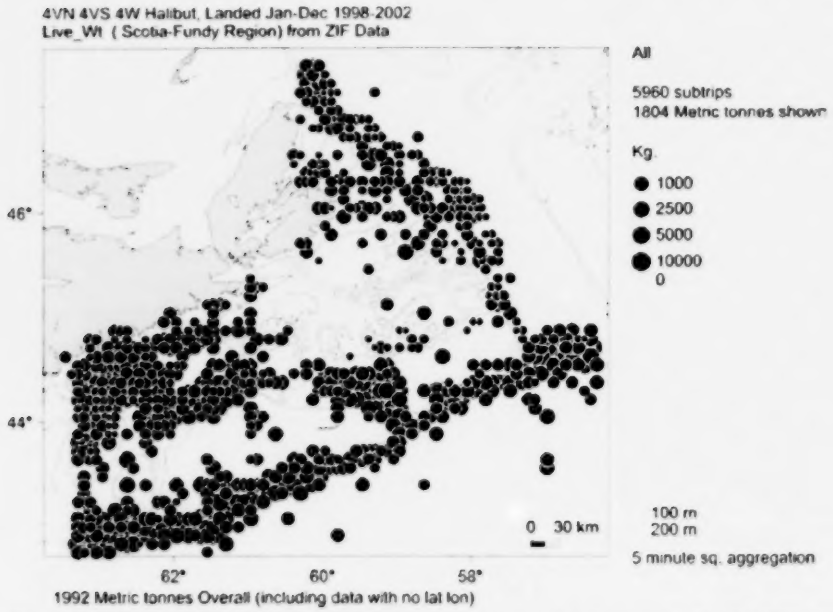


Figure 7. Location and landings from halibut fisheries, eastern Scotian Shelf (4VW), 1997-2002. Landings aggregated by 5-minute squares.

References (this section):

Auld, A. 2002. 'We couldn't believe our eyes': Scientists find reef-building coral near Sable Island. The Halifax Herald Ltd. 25 September 2002. Internet document. <http://www.herald.ns.ca/stories/2002/09/25/f163.raw.html> Accessed 7 January 2003.

Breeze, H., D.S. Davis, and M. Butler. 1997. Distribution and status of deep sea corals off Nova Scotia. Marine Issues Committee Special Publication Number 1. Halifax, NS: Ecology Action Centre.

Clapham, P. and F. Wenzel. 2002. Cruise Report, R/V Delaware II. Cruise No. DE 02-07. Large Whale Survey. 12 September 2002.

Collins, J.W. 1884. On the occurrence of corals on the Grand Banks. Bulletin of the U.S. Fish Commission 4: 237.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002. Whale, Humpback. Species at Risk Database. Internet document. <http://www.cosewic.gc.ca/eng/sct1/index_e.cfm> Accessed 27 December 2002.

Fossa, J.H. and P.B. Mortensen. 1998. The biodiversity of Lophelia reefs and methods for mapping and monitoring. Fisken og Havet 17. 95 pp.

Gass, S. E. 2002. An assessment of the distribution and status of deep sea corals in Atlantic Canada by using both scientific and local forms of knowledge. Master of Environmental Studies thesis. Dalhousie University, Halifax, NS.

MacIsaac, K., C. Bourbonnais, E. Kenchington, D. Gordon Jr. and S. Gass. 2001. Observations on the occurrence and habitat preference of corals in Atlantic Canada. In J.H.M Willison, J. Hall, S. Gass, E. Kenchington, M. Butler, and P. Doherty, eds. Proceedings of the First International Symposium on Deep Sea Corals. Halifax, NS: Ecology Action Centre and Nova Scotia Museum. pp. 58-75.

Mortensen, P.B. and H.T. Rapp. 1998. Oxygen and carbon isotope ratios related to growth line patterns in skeletons of *Lophelia pertusa* (L) (Anthozoa, Scleractinia): Implications for determination of linear extension rates. Sarsia 83. 433-446.

Waring, G.T., J.M. Quintal, and C.P. Fairfield, eds. 2002. Humpback Whale. In: U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2002 (DRAFT). National Marine Fisheries Service. pp. 14-27.

3.4 Shrimp Holes of the Eastern Scotian Shelf

Location: Middle shelf, eastern Scotian Shelf (Figure 8).

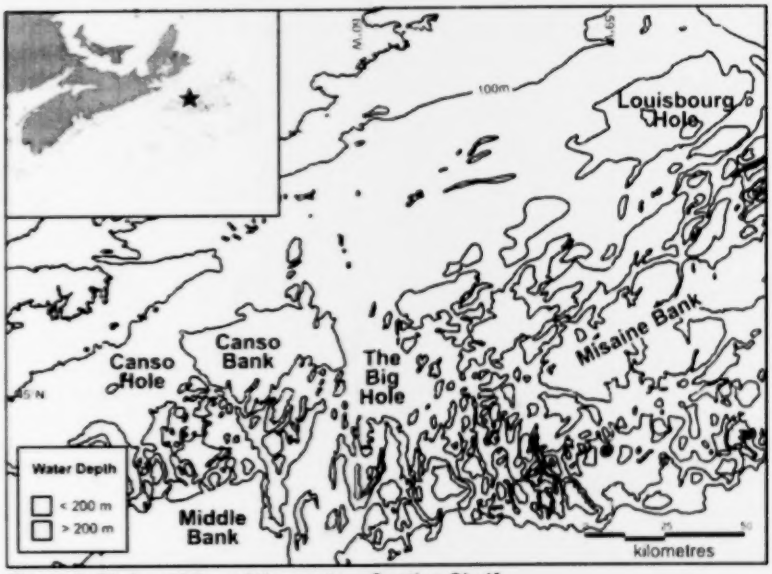


Figure 8. Shrimp Holes of the eastern Scotian Shelf.

Current Status: Closed to cod and haddock fisheries since 1993 (part of 4VSW closure). No management measures particular to the area.

Criteria (1): biological productivity, potentially other criteria (such as reproductive area)

Human Activities: Fishing (snow crab, shrimp), shipping, research activities, MARLANT exercise areas Q2 and Q3.

Importance:

- Concentrations of northern shrimp (including all life stages).
- Bottom sediments have high organic content.

Remarks: Northern shrimp (*Pandalus borealis*) are abundant on the eastern Scotian Shelf in the depressions surrounding Canso and Misaine Banks – the Big Hole, Misaine Hole, Louisbourg Hole, Whitehead Hole, Canso Hole, the Noodles, as well as several unnamed depressions (DFO 2002). These holes are the preferred habitat of shrimp because of substrate (fine silt with high organic content) and temperature (Koeller 1996). This area has cooler bottom temperatures relative to other parts of the shelf and is near the southern limits of the range of northern shrimp (there are also high concentrations of northern shrimp in the cool waters of the Gulf of Maine, further south).

Larvae are released in all these areas, although the timing seems to be somewhat different in inshore and offshore areas (Koeller 1996). The distribution of female and males,

juvenile, immature, and adult animals is somewhat different,[8] although all stages are found in the general area and there do not appear to be large scale inshore-offshore migrations like there are in other areas (Koeller 1996, Koeller 2000). There is movement between the different holes. Some larvae released in the general area are transported to the southwestern part of the Scotian Shelf and contribute to smaller populations there (Koeller 1996).

Snow crabs are also numerous in these holes. The cool waters and muddy bottoms found along the sides and at the bottom of these depressions are also their preferred habitat (DFO 1999).

The Louisbourg Line, a transect that is regularly sampled by oceanographers, crosses through this area. As a result, the hydrographic properties of the area are fairly well-known compared to other parts of the shelf. Despite this, there have been few research projects focussed solely on this area and the fauna of the area (other than the fish fauna) are not particularly well-known.

This area is of importance for shrimp and snow crab fisheries (Figures 9 and 10).

These deep areas are a relatively large part of the eastern Scotian Shelf. The holes have similar characteristics. Based on the available information, it was not possible to select any one of the depressions as more ecologically significant than the others.

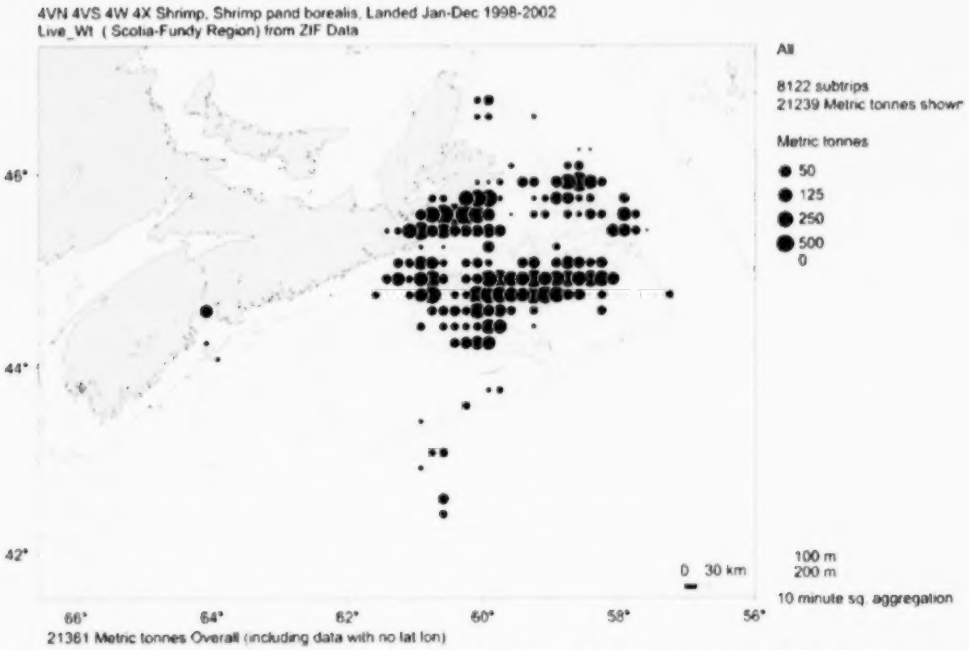


Figure 9. Shrimp landings from the Scotian Shelf (4VWX), 1998-2002, aggregated by 10-minute squares.

[8] Shrimp are hermaphrodites, functioning as males for the first part of their lives and changing sex at roughly age four to function as females for the remainder of their lives.

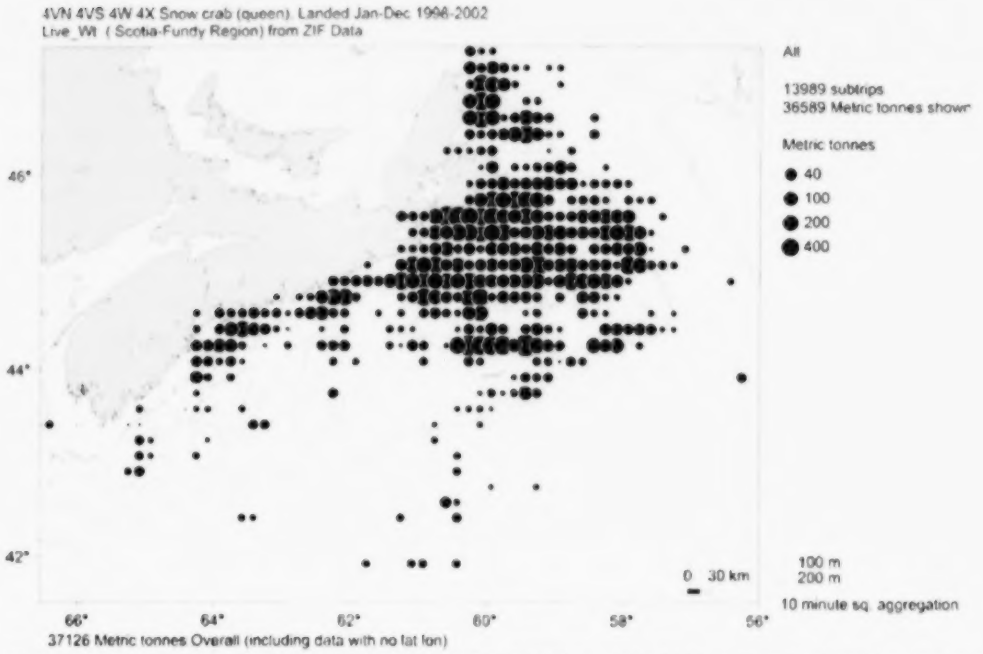


Figure 10. Snow crab landings from the Scotian Shelf (4VWX), 1998-2002, aggregated by 10-minute squares.

References (this section):

DFO (Fisheries and Oceans Canada). 2002. Northern shrimp on the eastern Scotian Shelf (SFA 13-15). DFO Science Stock Status Report C3-15.

DFO (Fisheries and Oceans Canada). 1999. Eastern Nova Scotia Snow Crab. DFO Science Stock Status Report C3-02.

Koeller, P. 1996. Aspects of the biology of northern shrimp *Pandalus borealis* on the Scotian Shelf. DFO Atlantic Fisheries Research Document 96/9.

Koeller, P.A. 2000. Relative importance of abiotic and biotic factors to the management of the northern shrimp (*Pandalus borealis*) fishery on the Scotian Shelf. Journal of Northwest Atlantic Fishery Science 27: 21-33.

3.5 Southwest Peak of Banquereau

Location: Southwest Banquereau, next to The Gully (Figure 11).

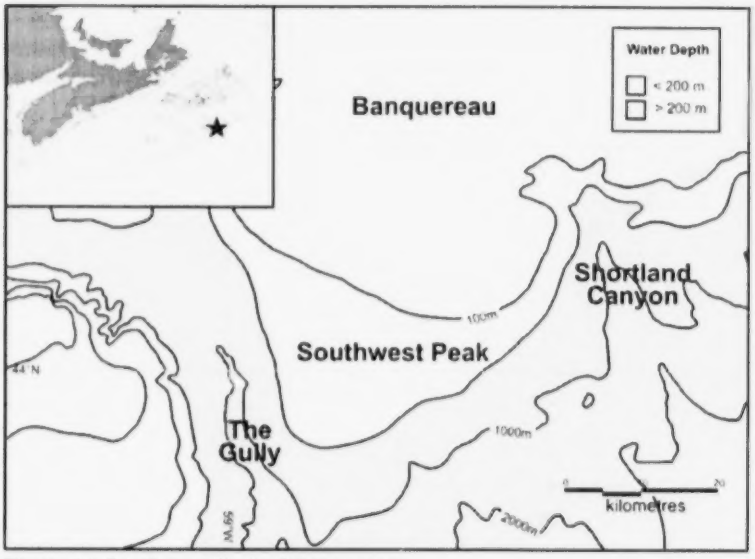


Figure 11. Southwest Peak of Banquereau.

Current Status: No management measures particular to the area, except for the portion that falls within the proposed Gully MPA (see section 3.5). Closed to fisheries for cod and haddock since 1993 (part of 4VSW closure).

Human Activities: fishing, petroleum exploration, shipping, research activities (regional studies).

Criteria (1): biological productivity, reproductive area, bottleneck area

Importance:

- High level of primary productivity, particularly during the fall.
- Potential nursery area for juvenile haddock.
- Groundfish concentrated there during winter.

Remarks: This part of Banquereau, east of and adjacent to The Gully, has strong internal tides (Sandstrom and Elliott 2002). The physiography of the area seems to encourage the formation of solitary waves that vertically mix the water column regularly with the semi-diurnal tide. The internal tides are particularly strong in the mid and late summer. These internal tides replenish nutrients in the euphotic zone and are likely the main impetus behind the fall bloom in the area (Sandstrom and Elliott 2002). The enhanced mixing of the water column will lead to increased primary productivity at other times of the year as well, if other conditions are appropriate. The oceanography of the region is closely tied with the surrounding areas, including The Gully.

Trawlers discarded high numbers of small haddock in the area in the mid-1980s, according to information from the International Observers Program (Fanning *et al.* 1987). The area was closed to groundfish fishing in 1987, along with the Emerald-Western Bank haddock nursery area (Figure 12). However, research surveys carried out in the spring, summer and fall did not find particularly high levels of juveniles (Fanning *et al.* 1987) and it was re-opened. It was a preferred haddock fishing ground in the mid-1980s (Fanning *et al.* 1987). There has been no directed fishery for haddock on the eastern Scotian Shelf since 1993.

Many groundfish species move to deeper waters in the fall and winter. The Southwest Peak is a broad, deep part of Banquereau that is used as an overwintering area by haddock and other groundfish. There is no research survey carried out in mid-winter; however, landings for January and February show catches in the Southwest Peak and Gully area by fishermen targeting these three species, suggesting concentrations of groundfish in the area in the pre-moratorium period (Figure 13). The Southwest Peak appears to have been a more important area for haddock than for the other two species (Figure 14). In the years since the moratorium, the main fisheries in the area have been for halibut and redfish. These species are fished along the edges of banks and along the slope – much the same areas where cod, haddock, and pollock overwinter – thus distribution maps showing bycatch of cod, haddock, and pollock in those fisheries have limited use and are not shown here. The 4VsW cod sentinel survey, carried out in March, shows concentrations of cod, haddock and pollock over the Southwest Peak (Figure 15), part of a continuum of late winter/early spring distribution along the shelf edge.

Scott (1988) noted the western part of Banquereau as a potential area of haddock concentration on the Scotian Shelf and Bay of Fundy, one of four areas highlighted. Core areas with concentrations of fish may be critical for fish populations, particularly for sub-populations of stocks (Frank and Shackell pers. comm.).

There are fisheries for Icelandic scallop and surf clam in the general area; however they tend to be carried out in waters shallower than 100 metres (see maps in Breeze 2002).

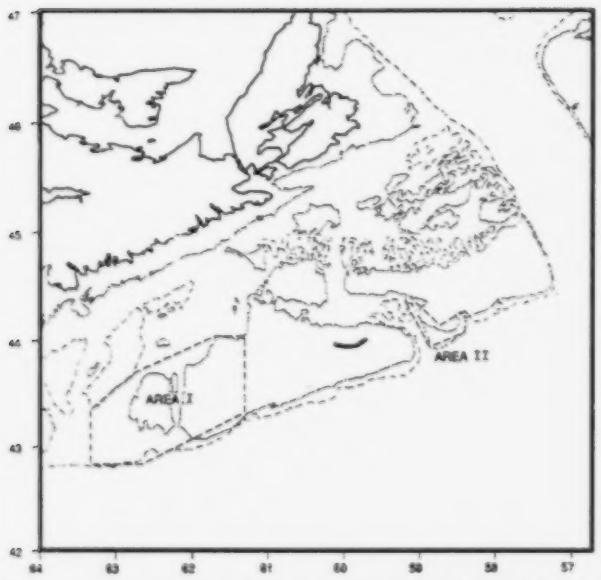


Figure 12. Areas closed in 1987 to protect juvenile haddock (from Fanning *et al.* 1987). Area II is the Southwest Peak juvenile area.

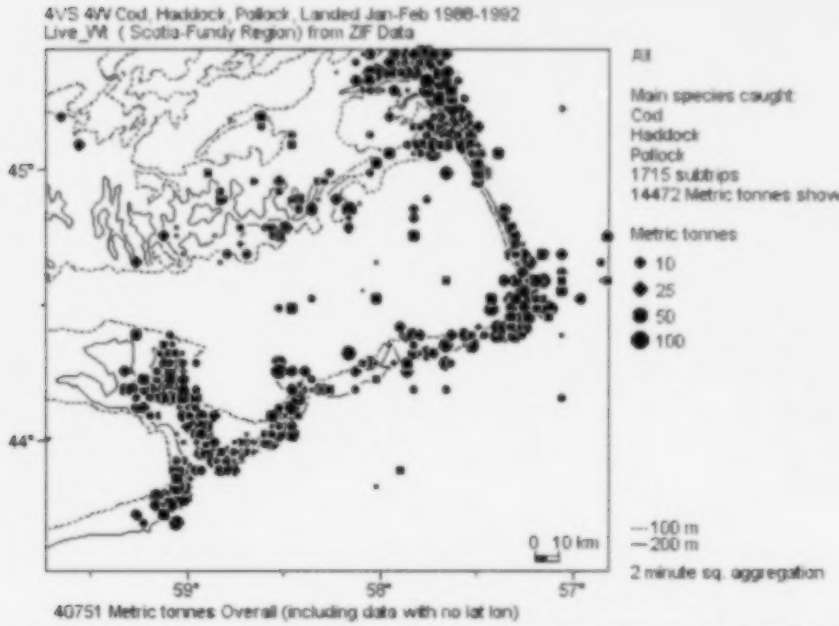


Figure 13. Cod, haddock and pollock landings for January and February, 1988-1992, with cod, haddock or pollock as the main species caught.

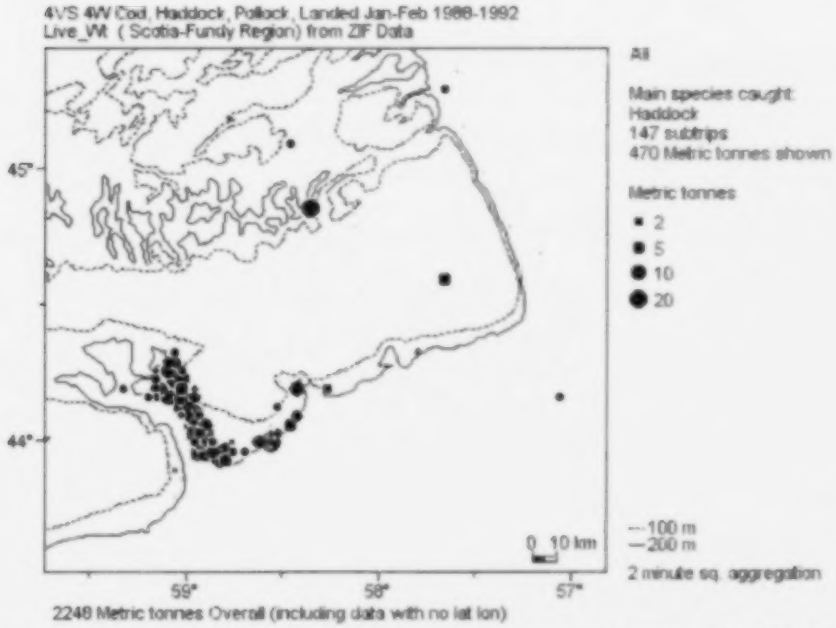


Figure 14. Cod, haddock and pollock landings for January and February, 1988-1992, with haddock as the main species caught.

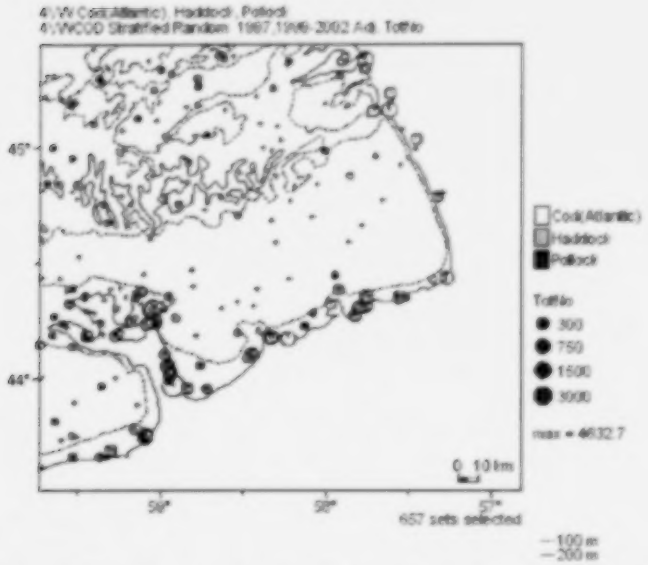


Figure 15. Cod, haddock and pollock caught during the 4VsW research trawl survey, March, 1997 and 1999-2002.

References (this section):

Breeze, H. 2002. Commercial fisheries of the Sable Gully and surrounding region: Historical and present activities. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2612.

Fanning, P., K. Zwanenburg, and M.A. Showell. 1987. Haddock nursery closed areas: delineation and impact. Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 87/59.

Sandstrom, H. and J.A. Elliott. 2002. Tidal mixing and The Gully ecosystem. In: D.C. Gordon and D.G. Fenton, eds. Advances in Understanding The Gully Ecosystem: A summary of research projects conducted at the Bedford Institute of Oceanography (1999-2001). Canadian Technical Report of Fisheries and Aquatic Sciences 2377. pp. 49-56.

Scott, J.S. 1988. Seasonal spatial distributions of groundfishes of the Scotian Shelf and Bay of Fundy, 1974-79 and 1980-84. Canadian Technical Report of Fisheries and Aquatic Sciences 1653.

Personal Communications:

Ken Frank and Nancy Shackell, Oceans Sciences Division, Fisheries and Oceans Canada, meeting with author, 13 December 2002.

3.6 The Gully

Location: Between Sable Island Bank and Banquereau (Figure 16).

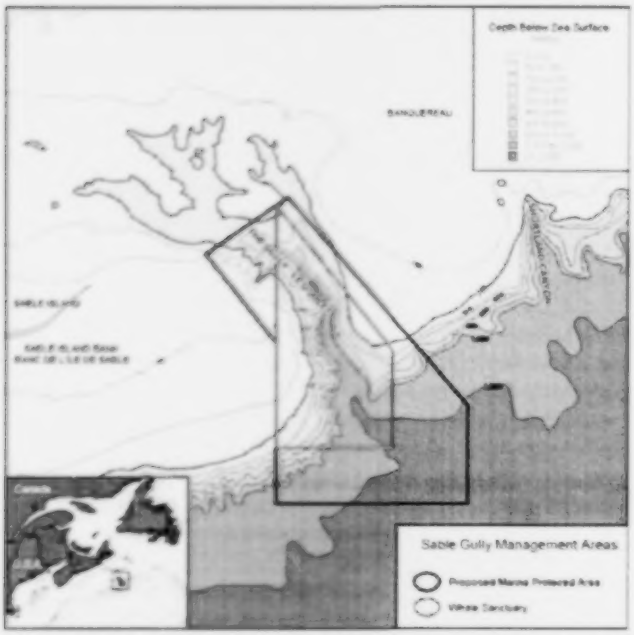


Figure 16. The Gully showing candidate marine protected area boundary and whale sanctuary boundary.

Current Status: Candidate marine protected area (Fisheries and Oceans Canada), Whale Sanctuary, closed to cod and haddock fisheries since 1993 (part of 4VSW closure).

Human Activities: Fishing (primarily for halibut and swordfish), submarine cable (abandoned), shipping, research activities, partially within MARLANT exercise area Q3.

Criteria (1): biological productivity, biodiversity, habitat for endangered and threatened species, rare/unique habitats and habitat for rare species, naturalness
(2): dependency, fragility/sensitivity

Importance:

- Many whales are found in the area and there are likely to be high concentrations of their prey.
- There is a diversity of habitat and species.
- Provides habitat for the endangered northern bottlenose whale and used by other endangered and threatened whales.
- It is one of only a few areas of the Scotian Shelf and slope known to have concentrations of corals.

- The Gully is a distinctive geological feature and is the largest submarine canyon off Eastern Canada and the United States. Unlike the other canyons along the slope, it extends well into the shelf and has a broad basin at its head.
- Because of its rough topography and great depths, The Gully has areas that are less accessible to fishing gear.
- Large, long-lived epibenthic fauna, such as the corals found in The Gully, are sensitive to human activities.
- The whales found in The Gully are sensitive to acoustic disturbances.
- At least at some times of the year, The Gully may concentrate particles, such as contaminants, because of its patterns of circulation.

Remarks: The Gully has been determined to be an area of ecological significance by several authors. It is part of the "Sable Island and The Gully" Natural Area of Canadian Significance identified by P. Lane and Associates (1992). For details on its features, see Harrison and Fenton (1998), Gordon and Fenton (2002), and Rutherford and Breeze (2002). An overview of fishing activities in The Gully can be found in Breeze (2002).

Habitats and species of The Gully may be more sensitive to human activity than other areas of the shelf and slope because of circulation patterns and the species found there. Large submarine canyons along the margin of Georges Bank have higher levels of trace metals than adjacent areas, likely due to patterns of circulation and particle resuspension in the canyons (see Boehm 1989, Bothner 1989). The long-lived epibenthic fauna, such as the corals found in The Gully, are sensitive to disturbance by bottom fishing gear and other human activity that disturbs bottom habitat. Animals that live in coral habitats are also affected.

References (this section):

Boehm, P.D. 1989. Overview of the biogenic and anthropogenic hydrocarbon distributions in sediments along the North Atlantic margin. In: Walcoff & Associates. Proceedings of the North Atlantic Submarine Canyons Workshop. February 7-9, 1989. Volume 1: synthesis summary. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region. OCS Study MMS 89-0016. pp. 52-58.

Bothner, M.H. 1989. The flux and composition of resuspended sediment in Lydonia Canyon: Implications for pollutant scavenging. In: Walcoff & Associates. Proceedings of the North Atlantic Submarine Canyons Workshop. February 7-9, 1989. Volume 1: synthesis summary. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region. OCS Study MMS 89-0016. pp. 36-51.

Breeze, H. 2003. Commercial fisheries of the Sable Gully and surrounding region: Historical and present activities. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2612.

Gordon, D.C. and D.G. Fenton, eds. 2002. Advances in Understanding The Gully Ecosystem: A summary of research projects conducted at the Bedford Institute of Oceanography (1999-2001). Canadian Technical Report of Fisheries and Aquatic Sciences 2377.

Harrison, W. G. and D.G. Fenton, eds. 1998. The Gully: A Scientific Review of Its Environment and Ecosystem. Canadian Stock Assessment Secretariat Research Document 98/83.

P. Lane and Associates. 1992. A Study to Identify Marine Natural Areas of Canadian Significance in the Scotian Shelf Marine Region. Project E-363. Prepared for Canadian Parks Service, Environment Canada.

Rutherford, R.J. and H. Breeze. 2002. The Gully Ecosystem. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2615.

3.7 Shortland and Haldimand Submarine Canyons

Location: Both canyons indent the northeast slope of the Scotian Shelf, south of Banquereau (Figure 17).

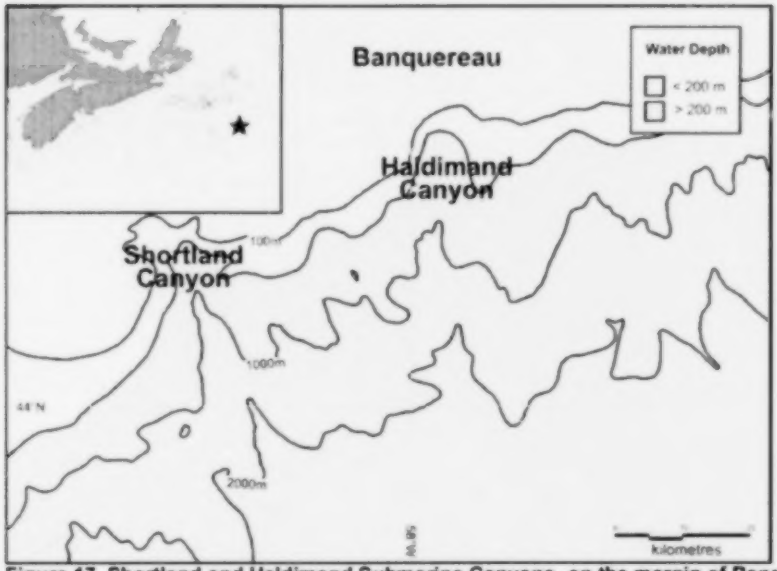


Figure 17. Shortland and Haldimand Submarine Canyons, on the margin of Banquereau.

Current Status: No special management measures for the area. Closed to fisheries for cod and haddock (part of 4VSW closure).

Human Activities: fishing, petroleum exploration, shipping, research activities, MARLANT exercise area Q3.

Criteria (1): habitat for endangered/threatened species, rare/unique habitat, other criteria likely correspond as well (biological productivity, biodiversity, naturalness and (2) fragility/sensitivity, significance)

Importance:

- Habitat for endangered northern bottlenose whales.
- Habitat for deep sea corals – a relatively rare habitat in the study area.
- Because whales are frequently found there, there are likely concentrations of their prey.
- Because of the very deep waters in the canyon, parts of it are less likely to have been disturbed by fishing gear.
- The deep sea corals of the area are sensitive to activities that disturb the ocean bottom; the toothed whales are sensitive to acoustic disturbances.

- The increasing interest in both whales and corals of the Scotian Shelf make it a site of interest for scientific research.

Remarks: Whitehead and Wimmer (2001) surveyed the slope of the Scotian Shelf and the northeastern United States along the 1000-metre isobath, from New Jersey to the southern Grand Banks. The 1000-metre isobath was considered to be the preferred depth for northern bottlenose whales. They found these whales in only three locations: The Gully, Shortland Canyon and Haldimand Canyon. The following year, they carried out research only in those three canyons (Wimmer *et al.* 2002). The three canyons are relatively close to one another and many of the whales photographed in Shortland and Haldimand Canyons had previously been photographed in The Gully (Wimmer *et al.* 2002). Because of the small size of the Scotian Shelf population of northern bottlenose whale, COSEWIC recently changed its conservation status to endangered (Whitehead and Wimmer 2002).

Deep sea corals in museum collections were collected from the two canyons and the area between them (Breeze *et al.* 1997). Fishermen have observed coral in the area and there are records from DFO groundfish trawl surveys (Breeze *et al.* 1997, Gass 2002). Gass (2002) identified the slope and canyons between the Laurentian Channel and The Gully as an area of relatively high coral species richness. She suggested that it may be a key area for *Keratoisis ornata* (gold-banded coral), as it was one of the few areas in her study of Atlantic Canada where *K. ornata* was reported. She also noted that Collins (1884) referred to this area as being more abundant in this species than other locations he had fished. Old fishing maps show corals in this area (Collins and Rathbun 1887).

Large gorgonian corals have a wide range but patchy distribution in Atlantic Canada (see Gass 2002). They are limited to areas with appropriate habitat: areas deeper than at least 150 metres (some species found much deeper), and areas with hard substrate and fast current flow (Hecker *et al.* 1980, Breeze *et al.* 1997, Gass 2002). Hard substrate is often found in areas with strong currents. The currents also move food regularly past the filter feeders.

Unique and special features have been found in submarine canyons around the world. Haldimand and Shortland Canyons and the nearby Gully are the only places off Nova Scotia where both endangered northern bottlenose whales are seen regularly and large gorgonian corals have been found. Strategic Environmental Assessments carried out for the CNSOPB have noted these canyons as "special areas" (CNSOPB 2000, CNSOPB 2002a). Exploration leases have been granted around the canyons but the canyons themselves are partially excluded (Figure 18).

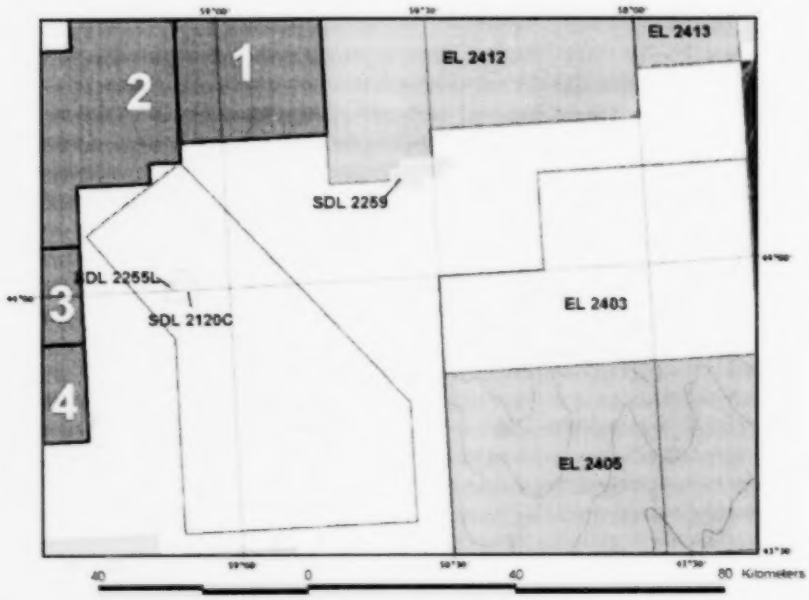


Figure 18. Exploration and significant discovery licenses in the area of The Gully, Shortland and Haldimand Canyons. Blocks with exploration licenses have labels starting with EL and blocks with significant discovery licenses have labels starting with SDL. The Gully proposed MPA is outlined in red. The red blocks are part of the most recent call for bids in the area.

References (this section):

Breeze, H., D.S. Davis, and M. Butler. 1997. Distribution and status of deep sea corals off Nova Scotia. Marine Issues Committee Special Publication Number 1. Halifax, NS: Ecology Action Centre.

CNSOPB (Canada-Nova Scotia Offshore Petroleum Board). 2000. Strategic Environmental Assessment. Parcels #1-8. Call for Bids NS00-1. CNSOPB, Halifax, NS.

CNSOPB. 2002a. Strategic Environmental Assessment of Potential Exploration Rights Issuance For Eastern Sable Island Bank, Western Banquereau Bank, the Gully Trough and the Eastern Scotian Slope. CNSOPB, Halifax, NS.

CNSOPB. 2002b. Canada-Nova Scotia Offshore Petroleum Board Offshore Interests. Internet document. <http://www.cnsopb.ns.ca/Maps/gully.html> Accessed 14 January 2003.

Collins, J.W. 1884. On the occurrence of corals on the Grand Banks. Bulletin of the U.S. Fish Commission 4: 237.

Collins, J.W. and R. Rathbun. 1887. The sea fishing grounds of the eastern coast of North American from Greenland to Mexico. In: G.B. Goode. The Fisheries and Fishery Industries of the United States. Section III: The Fishing Grounds of North America with Forty-Nine Charts. Washington: Government Printing Office. pp. 5-78.

Gass, S.E. 2002. An assessment of the distribution and status of deep sea corals in Atlantic Canada by using both scientific and local forms of knowledge. Master of Environmental Studies thesis. Dalhousie University, Halifax, NS.

Hecker, B., G. Blechschmidt, and P. Gibson. 1980. Epifaunal zonation and community structure in three mid- and North Atlantic Canyons. Final report for the canyon assessment study in the mid- and North Atlantic areas of the U.S. outer continental shelf. Prepared for the U.S. Department of the Interior, Bureau of Land Management.

Whitehead, H. and T. Wimmer. 2001. Research on bottlenose whales off Nova Scotia. Final report on research in 2001. Department of Biology, Dalhousie University.

Whitehead, H. and T. Wimmer. 2002. Update to the status of the northern bottlenose whale, *Hyperoodon ampullatus* (Scotian Shelf population). Prepared for COSEWIC.

Wimmer, T., H. Whitehead and J. Bock. 2002. Research on bottlenose whales off Nova Scotia. Final report on research in 2002. Department of Biology, Dalhousie University.

3.8 Middle Bank and Area

Location: Middle shelf, north of Sable Island Bank (Figure 19).

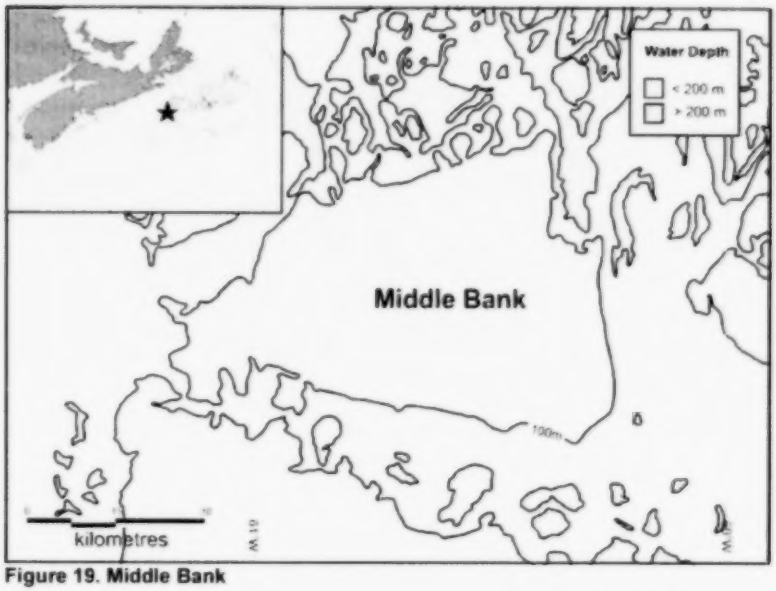


Figure 19. Middle Bank

Current Status: Closed to scallop fishing (voluntary closure), closed to cod and haddock fisheries since 1993 (part of 4VSW closure).

Human Activities: Fishing (limited), shipping, petroleum exploration, research activities (regional studies), MARLANT exercise area J.

Criteria (1): biological productivity, biodiversity
(2): significance (Scotian Shelf)

Importance:

- There are high levels of primary productivity in the area that may be exported to other areas of the shelf.
- There are indications of high adult fish diversity.
- There are indications of high larval fish diversity.

Remarks: This area has high levels of surface chlorophyll during the fall bloom (see Harrison *et al.* 2000) and likely also during the spring bloom. It is likely that some of the productivity from this area is exported to other regions of the shelf.

A study of adult fish diversity, using data from the groundfish research trawl survey, found that the area had relatively high species richness among bank areas (Frank and Shackell 2001). Part of the reason that Middle Bank was identified may have been a relatively high number of samples compared to other areas. A later study that accounted for sampling bias

identified an area just north of Middle Bank as having high species richness (Shackell and Frank 2003).

A study of larval fish diversity found that Middle Bank and the area just to the north of it were areas of high larval fish diversity (Shackell and Frank 2000). There is no information on the importance of the area as a spawning or nursery area and the high larval diversity does not in itself indicate high concentrations of spawning fish or a high survivability of larvae.

Middle Bank was an important scallop fishing area (Middle Grounds). There has been a voluntary closure in the area since 1997 to allow stocks to recover (DFO 2001).

There are few studies exclusively of Middle Bank and the regional-scale studies in which Middle Bank appears as an area of high adult and larval fish diversity have not examined the area in detail. Using existing information, it is not clear if Middle Bank ranks higher than other banks in terms of ecological significance.

References (this section):

DFO. 2001. Eastern Scotian Shelf Scallop. DFO Science Stock Status Report C3-19 (2001).

Frank, K.T. and N.L. Shackell. 2001. Area-dependent patterns of finfish diversity in a large marine ecosystem. Canadian Journal of Fisheries and Aquatic Sciences 58:1703-1707.

Harrison, G., B. Petrie, and T. Platt. 2000. Chlorophyll climatology of the continental shelf off Nova Scotia. Poster presented at the American Society of Limnology and Oceanography 2000 Ocean Sciences Meeting. San Antonio, Texas, 24-28 January 2000.

Shackell, N.L. and K.T. Frank. 2000. Larval fish diversity on the Scotian Shelf. Canadian Journal of Fisheries and Aquatic Sciences 57: 1747-1760.

Shackell, N.L. and K.T. Frank. 2003. Marine Fish Diversity on the Scotian Shelf, Canada. Aquatic Conservation: Marine and Freshwater Ecosystems 13: 305-321.

3.9 The Patch and Area

Location: Several small areas near Emerald Basin (Figure 20).

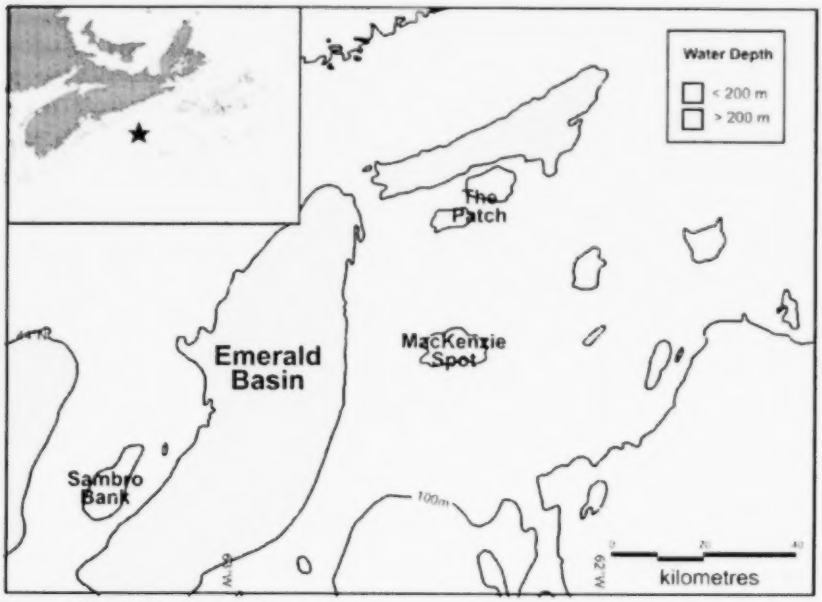


Figure 20. The Patch and area.

Current Status: No management measures particular to the area. Closed to cod and haddock fisheries since 1993 (part of 4VSW closure).

Human Activities: Fishing, shipping, research activities, MARLANT exercise areas E1, H1, G2.

Criteria (1): biodiversity, rare/unique habitat and habitat for rare species
(2): fragility/sensitivity, significance (Northwest Atlantic)

Importance:

- Unique population of the glass sponge *Vazella pourtalesi*.
- Glass sponges are sensitive to impacts by bottom fishing gear.
- Glass sponges are long-lived and slow growing.

Remarks: Fuller (2002) collected information from fishermen, examined bycatch records from fisheries observers, and used observations from scientific research cruises (ROPOS and CAMPOD) to gather information on sponge populations of the Scotian Shelf. Analysis of fisheries observer records for the Scotian Shelf suggested that many sponges were found in the area of the Patch and nearby areas by Emerald Basin and Sambro Bank. In her preliminary results, Fuller (2002) suggested that this area is a hotspot for sponges.

The glass sponge found in the area is *Vazella pourtalesi*, known to fishermen as Russian hats (Fuller 2002). Before this research, this sponge was recorded from only one other

location in the Northwest Atlantic, off Florida. Fuller suggests that it is a unique population as it is found quite shallow for glass sponges, at a mean depth of about 170 metres. There are rocks and boulders in the area, and this rough topography may have protected the sponges from impacts by fishing gear.

Studies of the impacts of trawling on sponges have found that there is a higher removal rate for sponges than is average for attached epifauna (see Wassenberg *et al.* 2002 for findings and a review of impacts of fishing gear on sponges). Large sponges are particularly vulnerable. Glass sponges are long-lived and slow-growing. For example, a study of glass sponges in deep waters off British Columbia observed no recruitment to the population over the course of a three-year study (Leys and Lauzon 1998). Growth rates averaged 1.98 cm/year and large sponges in the population were estimated to be 220 years old.

References (this section):

Fuller, S.D. 2002. Sponge distribution in the Northwest Atlantic: Preliminary analyses of observer records and trawl survey data. Presentation to coral discussion group. September, 2002. Dalhousie University, Halifax, Nova Scotia.

Leys, S.P. and N.R.J. Lauzon. 1998. Hexactinellid sponge ecology: growth rates and seasonality in deep water sponges. Journal of Experimental Marine Biology and Ecology 230: 111-129.

Wassenberg, T.J., G. Dews and S.D. Cook. 2002. The impact of fish trawls on megabenthos (sponges) on the north-west shelf of Australia. Fisheries Research 58: 141-151.

3.10 Sable Island and Shoals

Location: Sable Island and surrounding waters (Figure 21)

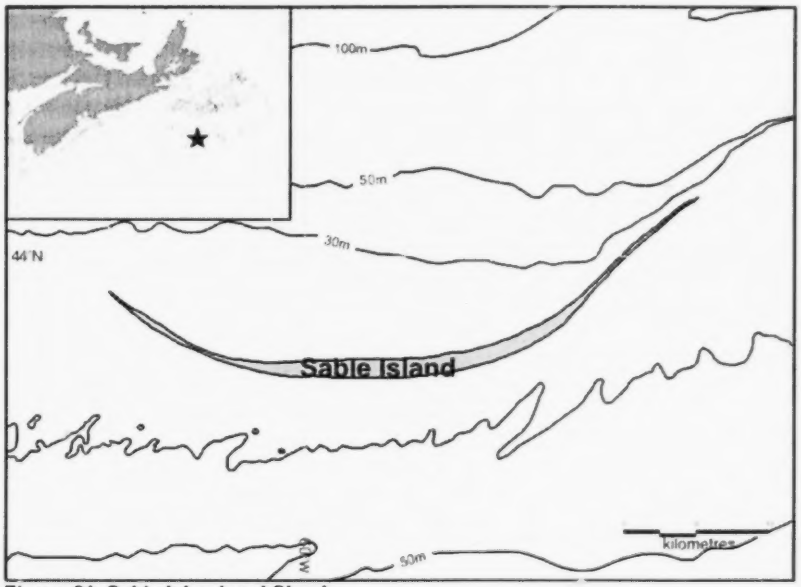


Figure 21. Sable Island and Shoals

Current Status: Sable Island is a Migratory Bird Sanctuary (federal designation). The Canada-Nova Scotia Offshore Petroleum Board has required that oil and gas companies operating in the area prepare a code of practice for Sable Island and has not allowed surface drilling on the island or one nautical mile around it.

Human Activities: Petroleum exploration. Petroleum development projects nearby. Drill cuttings have been deposited in the shallows around Sable Island. Several scientific studies are ongoing.

Criteria (1): reproductive area, habitat for endangered/threatened species, rare/unique habitat and species
(2): dependency, significant (some features Scotian Shelf, some Northwest Atlantic, some world), sensitivity/fragility

Importance:

- Nesting area for seabirds, including the endangered Roseate Tern.
- Breeding area for grey and harbour seals.
- Largest breeding population in grey seals in the world – more than half of the entire eastern Canadian population.
- Juvenile haddock are concentrated in the shoals around Sable Island, at least in some years.

- Only island of Nova Scotia's outer continental shelf.
- Several endemic terrestrial species.
- Globally significant populations of some seabirds.
- High value for scientific research, with many scientific studies of the island or based at the island. Many other studies are likely to be carried out.

Remarks: Sable Island was designated a Migratory Bird Sanctuary by the Canadian government, and many species of terns, gulls and waterfowl nest on the island. It is estimated that about 10 pairs of the nationally endangered Roseate Tern nest on the island. Common and Arctic Terns also nest on the island. Tern populations on the island have been decreasing due to predation by the increasing numbers of gulls. An initiative to manage the gull population was planned in the early 1990s but was publicly unpopular and not carried out (Bird Studies Canada 2002). According to the criteria used to select Important Bird Areas (an international NGO program), it is a nationally significant site (Bird Studies Canada 2002), with globally significant populations of some species (Common Tern, Great Black-backed Gull and Herring Gull).

The island is home to nearly the entire population of the Ipswich Sparrow (*Passerculus sandwichensis princeps*), a sub-species of the Savannah Sparrow. This land bird is listed by COSEWIC as a species of special concern due to its limited distribution (COSEWIC 2002).

The world's largest breeding population of grey seals pups on the island between mid-December and mid-January (Whitehead *et al.* 1998). This represents about half the grey seal population in eastern Canada (Whitehead *et al.* 1998). A small population of harbour seals pups on the island in May; this is thought to be the only offshore breeding location in Atlantic Canada for this abundant species (Whitehead *et al.*1998).

The island is important for several terrestrial species. There are at least two species of invertebrates endemic to the island, as well as populations of species found on the mainland that have distinct features on the island. There are also varieties of plants on the island that have characteristics different from their mainland relatives (Beson 1998, NSM/SIPT 2001).

Juvenile haddock (1 to 29 centimetres) appear to be highly concentrated in the shallows around the island, at least in some years (Scott 1984, Scott 1987, Frank *et al.* 2001). This shallow area is not regularly sampled by the groundfish research trawl survey.

As an isolated terrestrial environment, Sable Island is a unique habitat. It also presents unique opportunities for scientific investigations. Weather observations taken on the island provide a record from 1871 to the present. There has been extensive research on atmospheric conditions conducted from the weather station. Research on the isolated populations of plants and animals on the island have provided information on the extent of glaciers on the Scotian Shelf and on re-colonization rates (see Davis and Browne 1996). Marine mammal strandings on the island have provided information on the occurrence of marine mammals on the Scotian Shelf (Lucas and Hooker 2000).

Sable Island was part of the "Sable Island and The Gully" Natural Area of Canadian Significance identified by P. Lane and Associates (1992). This area was selected due to its important cultural features as well as its importance for Roseate Terns and grey seals. The island's environment was considered ecologically fragile and vulnerable to overuse.

The Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) has not allowed drilling on the island or within one nautical mile in recent calls for bids (CNSOPB 1998). There are several abandoned and capped exploration wells on the island and surrounding shallows dating from the late 1960s and early 1970s (NSDOE 2002). There are two wells currently in production within 10 kilometres of the island, part of the Sable Offshore Energy project (NSDOE 2002). In

recent years, the CNSOPB has required oil and gas companies operating in the area to prepare a Code of Practice for Sable Island (see e.g., SOEP n.d.).

References (this section):

Beson, K. 1998. Towards a conservation strategy for Sable Island. Environment Canada, Canadian Wildlife Service, Atlantic Region.

Bird Studies Canada. 2002. Sable Island, Nova Scotia. IBA Site Summary. Internet document. <http://www.bsc-eoc.org/iba/site.cfm?siteID=NS025&lang=en> Accessed 11 December 2002.

CNSOPB (Canada-Nova Scotia Offshore Petroleum Board). 1998. Board announces NS98-2 Call for Bids. Press Release. December 2. Internet document. <http://www.cnsopb.ns.ca/Whatsnew/press12-02-98.html> Accessed 14 February 2003.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002. Sparrow princeps subspecies, Savannah. Internet document. <http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm> Accessed 21 February 2003.

Davis, D.S. and S. Browne, eds. 1996. The Natural History of Nova Scotia. 2 vols. Halifax, NS: Nimbus/Nova Scotia Museum.

NSDOE (Nova Scotia Department of Energy). 2002. Activity Map. Nova Scotia Onshore and Offshore Regions. Internet document. <http://www.gov.ns.ca/energy/onoffmap/inset1.asp> Accessed 24 February 2003.

Frank, K.T., R.K. Mohn, and J.E. Simon. 2001. Assessment of the status of Division 4TVW haddock: 2000. Canadian Stock Assessment Secretariat Research Document 2001/100.

Lucas, Z.N. and S.K. Hooker. Cetacean strandings on Sable Island, Nova Scotia. 1970-1998. The Canadian Field-Naturalist 114(1): 45-61.

NSM/SIPT (Nova Scotia Museum and Sable Island Preservation Trust). 2001. Sable Island: A Story of Survival. Internet document. <http://collections.ic.gc.ca/sableisland> Accessed 19 February 2001.

P. Lane and Associates. 1992. A Study to Identify Marine Natural Areas of Canadian Significance in the Scotian Shelf Marine Region. Project E-363. Prepared for Canadian Parks Service, Environment Canada.

Scott, J.S. 1984. Short-term changes in distribution, size and availability of juvenile haddock around Sable Island off Nova Scotia. Journal of Northwest Atlantic Fisheries Science 5: 109-112.

Scott, J.S. 1987. Trawl surveys for juvenile groundfish in the Sable Island area, Nova Scotia, 1981-85. Canadian Technical Report of Fisheries and Aquatic Sciences 1532.

SOEP (Sable Offshore Energy Project). n.d. Sable Island Codes of Practice. Internet document. <http://www.soep.com/cgi-bin/getpage?pageid=1/8/1> Accessed 15 August 2003.

Whitehead, H., W.D. Bowen, S.K. Hooker, and S. Gowans. 1998. Marine Mammals. In: W.G. Harrison and D.G. Fenton, eds. The Gully: A Scientific Review of Its Environment and Ecosystem. Canadian Stock Assessment Secretariat Research Document 98/83. pp. 186-221.

3.11 Western Bank-Emerald Bank Complex (Haddock Box)

Location: Emerald-Bank, Western Bank, Western Gully (Figure 22)

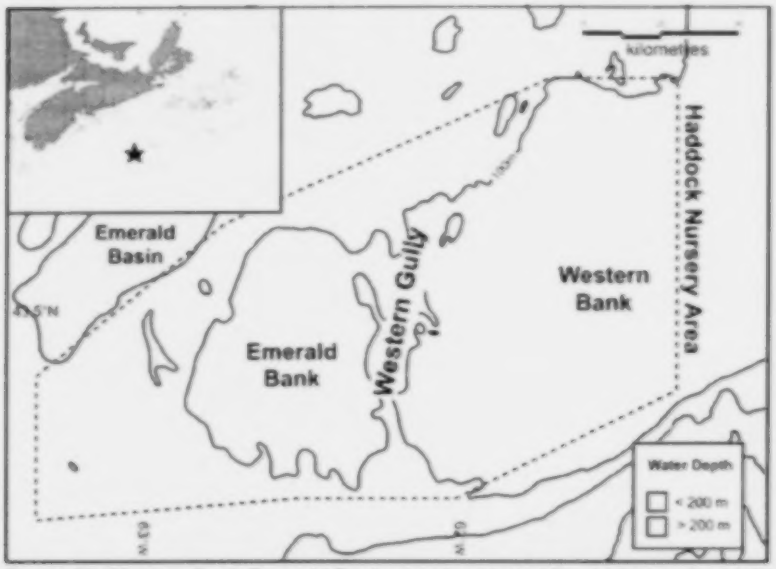


Figure 22. Western Bank-Emerald Bank complex (dotted line indicates the haddock nursery area).

Current Status: The area outlined by the polygon (Figure 22) has been closed to groundfish fishing (all gears) since 1993. Mobile gear targeting groundfish has been excluded since 1987. NAFO areas 4VSW were closed to fisheries for cod and haddock in 1993, so there has been little groundfish fishing even in the area outside the polygon since 1993.

Human activities: Scallop fishing, petroleum exploration, shipping, submarine cables (abandoned), research activities, MARLANT exercise areas G3, H1, H2, H3 and H4.

Criteria (1): biodiversity, reproductive area, habitat for endangered/threatened species
(2): fragility/sensitivity, significant (Scotian Shelf)

Importance:

- Spawning area for groundfish, particularly haddock and cod.
- Area of larval haddock that both remain in the area and disperse to other areas of the Scotian Shelf.
- Area of high larval fish diversity.
- Nursery area for juvenile haddock.
- Area of high marine fish diversity.

- There are indications of benthic species richness compared with other large banks of the Scotian Shelf.

- There are many whale sightings from the area of the Western Gully and the area west of Emerald Bank. Many species have been observed or caught, including endangered blue and right whales, and fin whales, a species of special concern.

- Pelagic seabirds are found regularly over Emerald Bank, the Western Gully and at the shelf edge in this area, particularly concentrations of Dovekies (seabirds, particularly auks such as Dovekies, are sensitive to petroleum in the water).

Remarks: Haddock spawn over pebble-gravel or sandy gravel bottom in relatively well-defined areas of the Scotian Shelf. Larvae are pelagic. When juveniles settle to the bottom (age 3 to 5 months, 5 to 10 centimetres), they are thought to have better survival rates in pebble-gravel or sandy gravel (Cargnelli *et al.* 1999). Large areas of both Emerald and Western Banks have gravel or sand-gravel areas. Emerald Bank may have been more important historically than it is at present. Some of the haddock spawned in the area appear to move to Sable Island Bank as larvae or juveniles. Frank *et al.* (2000) noted a high proportion of juveniles (ages 1 and 2) on Sable Island Bank in the 1987-1997 period. In some years, there are high concentrations of juveniles in the shallows around Sable Island. The box's current configuration should be evaluated should groundfish fishing activities in the surrounding area be reopened. It might also be appropriate to evaluate the boundaries in light of other human activities in the area.

Frank *et al.* (2000) evaluated the success of the closed area in improving the stock condition of haddock. Although increased recruitment and spawning stock biomass of haddock do not appear to have occurred, the closure has benefited other species. Populations of American plaice and winter flounder increased in the box and other species may also have benefited. Recent research by Fisher and Frank (2002) has found that the closure also appeared to lead to increased levels of certain fishes on Browns Bank and nearby areas at the mouth of the Bay of Fundy. DFO is carrying out other research on links between fish habitat and fisheries, and is looking at the Western Bank area in detail (see CMB 2003).

Frank and Simon (1998) examined bycatch from scalloping activities in the closed area. Bycatch of most groundfish species was fairly low in this fishery, with the sole exception of monkfish, with bycatch levels of 21 to 241 tonnes per year for the period 1989 to 1997. While bycatch is an important concern, the reworking of surficial sediments by the scallop drag should also be evaluated. As mentioned above, the pebble-gravel or sandy-gravel bottom habitat appears to be important for juvenile haddock and changes in this habitat may be deleterious to their survival. Much of the Western Bank portion of the Haddock Box has been fished by scallop vessels (Figure 23).

Cod spawn over the outer banks of the Scotian Shelf and Reiss *et al.* (2000) concluded that Western Bank was the most important bank of the central part of the shelf. It should be noted that the area they included with "Western Bank" portions of Sable Island Bank to the east and northeast of the closed area. Juvenile cod have been associated with cobble substrates in several studies and the larger sediment size may afford them protection from predation, particularly from adult cod. The widespread gravel bottoms of Western Bank and western Sable Island Bank would provide appropriate habitat.

Information from the Scotian Shelf Ichthyoplankton Program (SSIP) identified Emerald Bank as an important location for cod larvae. It may have been more important in the past when there was a spring spawning peak. Recent sampling has shown little evidence of cod spawning on the bank (Reiss, pers. comm.). The spring spawning component appears to have been largely lost due to overfishing (Frank *et al.* 1994). It should be noted that there have been more extensive studies of Western Bank than other parts of the shelf and it is difficult to assess the

area in a regional context because most other areas lack detailed information. There are suggestions in the literature that inshore nursery areas with eelgrass or macroalgae cover may be important (see e.g., Keats *et al.* 1987, Gotceitas *et al.* 1997).

Other groundfish species spawn in the area. They have not been studied in the detail that cod and haddock have.

A study examining potential indicators of benthic biodiversity found that Western Bank had higher indicators of species richness than Banquereau, Sable Island and Emerald Banks (Henry *et al.* 2002). However, the study looked at only one area of each bank. More studies should be carried out to explore this finding.

Whalers caught many whales in the Western Gully and over the adjacent banks in the late 1960s and early 1970s (Sutcliffe and Brodie 1977). Fin whales appear to have been particularly abundant in the area. In September 1966, whalers caught 51 fin whales in the Western Gully area. They returned in other years to make smaller catches (data in Sutcliffe and Brodie 1977). Right whales, humpback whales, blue whales, sei whales, minke whales, sperm whales and common dolphins have also been observed in the area (see Mitchell *et al.* 1986, Kenney 1994). Other species of dolphins and long-finned pilot whales are also likely to occur there (Reeves 2000). Most of the fin whales caught by whalers in the area had been feeding on krill (data in Sutcliffe and Brodie 1977). Blue whales and humpback whales also feed on concentrations of krill.

The North Atlantic right whale and the blue whale are listed as endangered species by COSEWIC. Fin whales are listed as a species of special concern. The fin whale was listed because of the heavy impact whaling had on the late-maturing, long-lived species (Meredith and Campbell 1987, COSEWIC 2002). An effort should be made to survey the Western Gully area for whales, along with Emerald Basin, the shelf and slope to the south of the basin, and Emerald Bank (those areas also had high catches and observations of whales). American researchers tried to survey the area in the summer of 2002, but the days set aside for the Western Gully and Emerald Basin had heavy fog (Clapham and Wenzell 2002).

Pelagic seabirds are found in this area, as they are over all the outer shelf banks. Maps in Brown (1988) showed the area of the Western Gully-Emerald Bank and the shelf edge to the south had high concentrations of Dovekies in winter. However, there are few or no observations for large areas of the shelf, and as a result, it is hard to compare seabird distributions of different areas of the shelf. Pelagic seabirds are sensitive to small amounts of petroleum in the water and can become seriously injured or die (Lock *et al.* 1994). In offshore areas, Dovekies and other auks are particularly vulnerable because they spend much time in the water (Gaston 1995). Although large oil spills cause high numbers of birds to become oiled and die, small discharges by vessels are also a significant ongoing cause of mortality in seabirds (Gaston 1995).

Connections with Sable Island Bank

Many of the special features attributed to Western Bank are shared with Sable Island Bank. The currents and other oceanographic characteristics of the two banks are closely connected. There is a partial gyre in the Western-Sable Island Bank region and the strength and position of the gyre varies (Hannah *et al.* 2001).

Western Bank and Sable Island Bank were found to be areas of high larval fish diversity and the researchers grouped the two banks together in their findings (Shackell and Frank 2000). Large bank areas, such as Sable Island and Western Banks, were found to be areas of high adult fish diversity when compared with other bank areas of the Scotian Shelf (Frank and Shackell 2001). When compared with other areas of the Scotian Shelf in general, Western Bank was found to have high adult fish diversity (Shackell and Frank 2003).

Concentrations of silver hake eggs and larvae are found in the summer in the area overlapping the two banks (Rikhter et al. 2001, Figure 24). Russian scientists studying silver

hake refer to the area as Sable Island Bank (Rikhter et al. 2001). In another study of silver hake, Jeffrey and Taggart (2000) focussed on Western Bank and the western portion of Sable Island Bank and referred to the whole area as Western Bank. Fader (pers. comm.) notes that Western Bank could be considered a deeper portion of Sable Island Bank, although the two banks may have had different glacial histories. The close connections between the two banks should be recognized in management measures particular to the area.

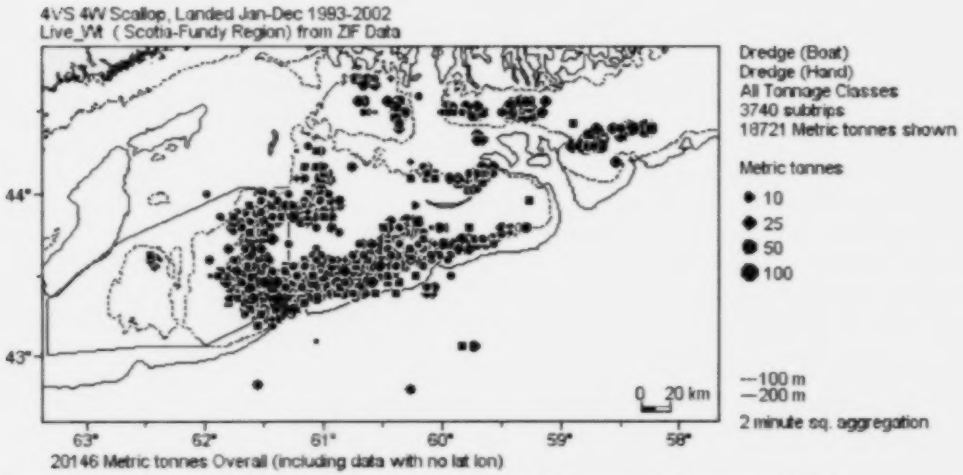


Figure 23. Location of scallop fishing activity in the area of the haddock box, 1993-2001.

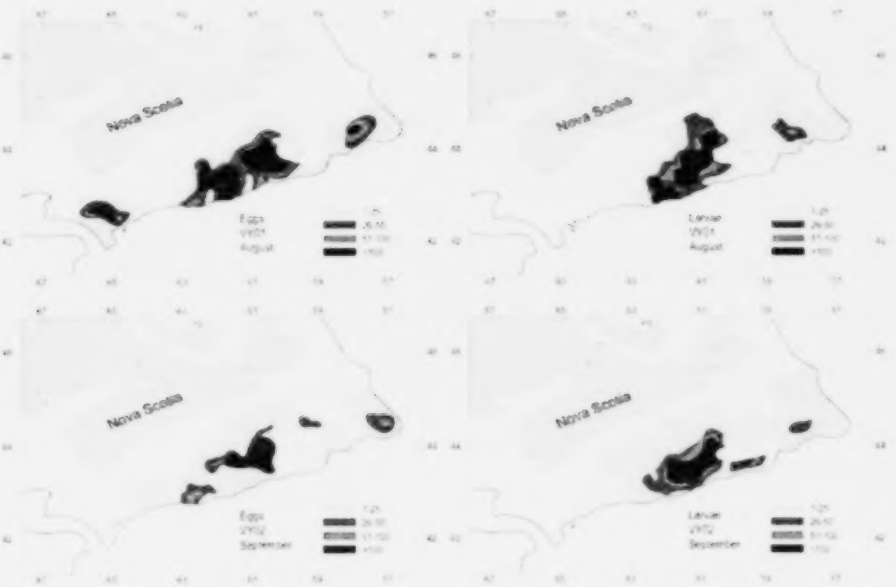


Figure 24. Locations where silver hake eggs and larvae were concentrated in August and September 1978 (from Rikhter et al. 2001 based on Noskov et al. 1979).

References (this section):

Brown, R.G.B. 1988. Oceanographic Factors as determinants of the winter range of the Dovekie (*Alle alle*) off Atlantic Canada. Colonial Waterbirds 11: 176-180.

Cargnelli, L.M., S.J. Griesbach, P.L. Berrien, W.W. Morse, and D.L. Johnson. 1999. Haddock, *Melanogrammus aeglefinus*, life history and habitat characteristics. Essential Fish Habitat Source Document. NOAA Technical Memorandum, NMFS-NE-128.

Clapham, P. and F. Wenzel. 2002. Cruise Report, R/V Delaware II. Cruise No. DE 02-07. Large Whale Survey. 12 September 2002.

CMB (Centre for Marine Biodiversity). 2003. Research. Understanding the links between habitat and fisheries. Internet document. <http://marinebiodiversity.ca/researchESSIM.htm> Accessed 5 February 2003.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002. Whale, Humpback. Species at Risk Database. Internet document. <http://www.cosewic.gc.ca/eng/sct1/index_e.cfm> Accessed 27 December 2002.

Fisher, J.A.D. and K.T. Frank. 2002. Changes in finfish community structure associated with an offshore fishery closed area on the Scotian Shelf. Marine Ecology Progress Series 240: 249-265.

Frank, K.T., K.F. Drinkwater, and F.H. Page. 1994. Possible causes of recent trends and fluctuations in Scotian Shelf/Gulf of Maine cod stocks. ICES Marine Science Symposia 198: 110-120.

Frank, K.T., N.L. Shackell, and J.E. Simon. 2000. An evaluation of the Emerald/Western Bank juvenile haddock closed area. *ICES* Journal of Marine Science 57: 1023-1034.

Frank, K.T. and N.L. Shackell. 2001. Area-dependent patterns of finfish diversity in a large marine ecosystem. Canadian Journal of Fisheries and Aquatic Sciences 58:1703-1707.

Frank, K.T. and J.E. Simon. 1998. An evaluation of the Emerald/Western Bank juvenile haddock closed area. Canadian Stock Assessment Secretariat Research Document 98/53.

Gaston, A.J. 1995. Seabirds. Canadian Hinterland Who's Who. Internet document. <http://www.cws-scf.ec.gc.ca/hww-fap/hww-fap.cfm?ID_species=42&lang=e. Accessed 7 January 2003.

Gotceitas, V., S. Fraser, and J.A. Brown. 1997. Use of eelgrass beds (*Zostera marina*) by juvenile Atlantic cod (*Gadus morhua*). Canadian Journal of Fisheries and Aquatic Sciences 54: 1306-1319.

Hannah, C.G., J.A. Shore, J.W. Loder and C.E. Naimie. 2001. Seasonal circulation on the western and central Scotian Shelf. Journal of Physical Oceanography 31: 591-615.

Henry, L., E. Kenchington, D.C. Gordon, Jr., K. MacIsaac, and C. Bourbonnais. 2002. Indicators of benthic biodiversity for the eastern Scotian Shelf. Canadian Technical Report of Fisheries and Aquatic Sciences 2433.

Jeffrey, J.A. and C.T. Taggart. 2000. Growth variation and water mass associations of larval silver hake (*Merluccius bilinearis*) on the Scotian Shelf. Canadian Journal of Fisheries and Aquatic Sciences 57: 1728-1738.

Keats, D.W., D.H. Steele, and G.R. South. 1987. The role of fleshy macroalgae in the ecology of juvenile cod (*Gadus morhua* L.) in inshore waters off eastern Newfoundland. Canadian Journal of Zoology 65: 49-53.

Kenney, R.D. 1994. Appendix 2: Distribution charts of marine mammals on the Scotian shelf, 1966 through 1992. In: R.R. Reeves and M.W. Brown. Marine mammals and the Canadian patrol frigate shock trials: A literature review and recommendations for mitigating the impacts. Prepared for National Defence Headquarters in support of Canadian Patrol Frigate Project Shock Trial. pp. 44-89.

Lock, A.R., Brown, R.G.B. and Gerriets, S.H. 1994. Gazetteer of Marine Birds in Atlantic Canada: An Atlas of sea bird vulnerability to oil pollution. Canadian Wildlife Service, Atlantic Region, Environment Canada.

Meredith, G. N. and R. R. Campbell. 1987. Status report on the fin whale, *Balaenoptera physalus*, in Canada. Prepared for the Committee on the Status of Endangered Wildlife in Canada. 42 pp.

Mitchell, E., V.M. Kozicki, and R.R. Reeves. 1986. Sightings of right whales, *Eubalaena glacialis*, on the Scotian Shelf, 1966-1972. Report of the International Whaling Commission Special Issue 10: 83-103.

Noskov, A.S., A.I. Sherstyukov, and A.N. Romanchenko. 1979. Distribution and abundance of silver hake eggs, larvae, and juveniles and environmental conditions off Nova Scotia in August-October 1978. *ICNAF Research Document* 79/VI/100.

Reeves, R. 2000. Marine Mammals. In: LGL Limited. Environmental Assessment of Exploration Drilling off Nova Scotia. Prepared for the Canada/Nova Scotia Offshore Petroleum Board. August. pp. 85-127.

Reiss, C.S., G. Panteleev, C.T. Taggart, J. Sheng, and B. deYoung. 2000. Observations on larval fish transport and retention on the Scotian Shelf in relation to geostrophic circulation. Fisheries Oceanography 9: 195-213.

Rikhter, V.A., I.K. Sigaev, V.A. Vinogradov, and V.I. Isakov. 2001. Silver hake of Scotian Shelf: Fishery, environmental conditions, distribution, and biology and abundance dynamics. Journal of Northwest Atlantic Fisheries Science 29: 51-92.

Shackell, N.L. and K.T. Frank. 2000. Larval fish diversity on the Scotian Shelf. Canadian Journal of Fisheries and Aquatic Sciences 57: 1747-1760.

Shackell, N.L. and K.T. Frank. 2003. Marine Fish Diversity on the Scotian Shelf, Canada. *Aquatic Conservation: Marine and Freshwater Ecosystems 13: 305-321.*

Sutcliffe Jr., W.H. and P.F. Brodie. 1977. Whale Distribution in Nova Scotia Waters. Fisheries and Marine Service Technical Report 722.

Personal communications

Gordon Fader, Research Scientist, Geological Survey of Canada (Atlantic), Natural Resources Canada, 27 June 2003.

Christian Reiss, Fisheries Oceanographer, Old Dominion University, Norfolk, Virginia. Personal communication with author, 14 November 2001.

3.12 Emerald Basin

Location: Central Scotian Shelf (Figure 25).

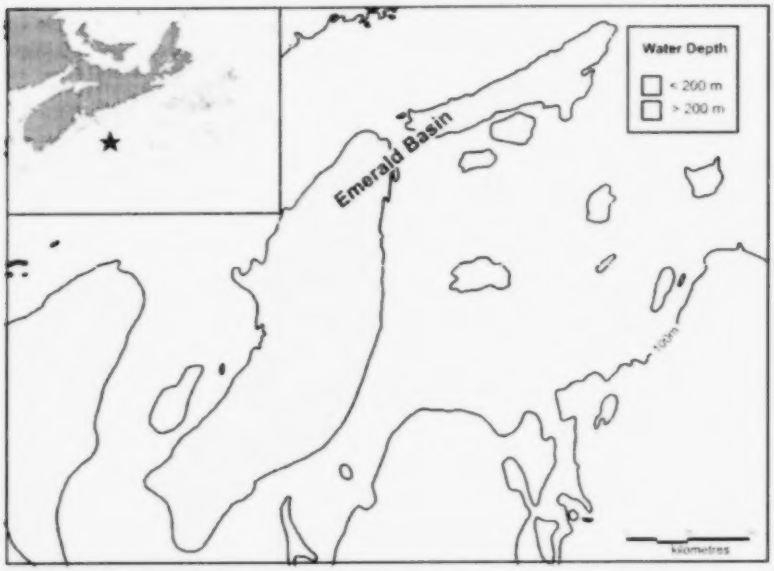


Figure 25. Emerald Basin

Current Status: Closed to cod and haddock fisheries since 1993 (part of 4VSW closure)

Human Activities: Fishing (silver hake, some Jonah crab), shipping, research activities, submarine cable, MARLANT exercise areas E1, H1, G2 and G3.

Criteria (1): biological productivity, reproductive area, habitat for endangered/threatened species
(2): significance (Scotian Shelf)

Importance:

- Overwintering area for the copepod *Calanus finmarchicus*.
- High densities of krill.
- Overwintering area for juvenile and adult silver hake.
- Probable regular feeding area for whales, some of which are endangered.

Remarks: The copepod *Calanus finmarchicus* is the most important component of the Scotian Shelf zooplankton community in terms of biomass, abundance, and secondary production. Emerald and LaHave basins are overwintering areas for this species (Sameoto and Herman 1990). Copepods are food for larval fish and invertebrates. There are also dense concentrations of krill found in the area (Sameoto and Cochrane 1996). These large zooplankton are prey for many other species.

Young silver hake (age-0) move to Emerald Basin and other deep water areas of the shelf to overwinter in preferred temperatures (see Koeller et al. 1989, Rikhter et al. 2001). They remain in the pelagic zone and migrate from the bottom to the surface at night (Koeller et al. 1986, Koeller et al. 1989). Their diurnal migration is tied to the movements of the krill (*Meganyctiphanes norvegica*) on which they feed (Sherstyukov and Nazarova 1991). Adult silver hake are concentrated in the basins during winter as well (Rikhter et al. 2001).

The abundance of zooplankton in the basin makes it an attractive feeding area for many species. For example, whales have been frequently observed in the southern part of Emerald Basin (see maps in Kenney 1994). Two endangered whales, the northern right whale and the blue whale, have both been observed in the basin, as have fin whales, a species of special concern (observations from Sutcliffe and Brodie 1977 and maps in Kenney 1994).

Emerald Basin has been noted for the high number of pockmarks found in its muddy sediments. Pockmarks are found in muddy sediments across the Scotian Shelf, perhaps formed by gas venting from subsurface gas-charged sediments (Josenhans et al. 1978). Emerald Basin has one of the greatest densities of pockmarks on the shelf (Fader 1991).

Oceanographic observations are made on a regular basis at a series of stations stretching from Nova Scotia's coast to the slope, known as the Halifax Line. Emerald Basin is included among the stations and as a result, features of this area have been studied in some detail. LaHave Basin has similar features to Emerald Basin (e.g., overwintering copepods, concentrations of krill) but has not been studied as extensively. Further research on LaHave Basin may deem it to be more important relative to Emerald Basin.

References (this section):

Fader, G.B.J. 1991. Gas-related sedimentary features from the eastern Canadian continental shelf. *Continental Shelf Research* 11: 1123-1153.

Josenhans, J.J., L.H. King and G.B.J. Fader 1978. A sidescan sonar mosaic of pockmarks on the Scotian Shelf. Canadian Journal of Earth Sciences 15: 831-840.

Kenney, R.D. 1994. Appendix 2. Distribution charts of marine mammals on the Scotian shelf, 1966 through 1992. In: R.R. Reeves and M.W. Brown. Marine mammals and the Canadian patrol frigate shock trials: A literature review and recommendations for mitigating the impacts. Prepared for National Defence Headquarters in support of Canadian Patrol Frigate Project Shock Trial. pp. 44-89.

Koeller, P.A., P.C.F. Hurley, P. Perley, and J.D. Neilson. 1986. Juvenile fish surveys on the Scotian Shelf: implications for year-class size assessments. Journal du Conseil international pour l'exploration de la mer 43: 59-76.

Koeller, P.A., L. Coates-Markle, and J.D. Neilson. 1989. Feeding ecology of juvenile (age-0) silver hake (*Merluccius bilinearis*) on the Scotian Shelf. Canadian Journal of Fisheries and Aquatic Sciences 46: 1762-1768.

Rikhter, V.A., I.K. Sigaev, V.A. Vinogradov, and V.I. Isakov. 2001. Silver hake of Scotian Shelf: Fishery, environmental conditions, distribution, and biology and abundance dynamics. Journal of Northwest Atlantic Fisheries Science 29: 51-92.

Sameoto, D. and N. Cochrane. 1996. Euphausiids on the Eastern Continental Shelf. DFO Atlantic Fisheries Research Document 96/119.

Sameoto, D.D. and A.W. Herman. 1990. Life cycle and distribution of *Calanus finmarchicus* in deep basins on the Nova Scotia shelf and seasonal changes in *Calanus* spp. Marine Ecology Progress Series 66: 225-237.

Sherstyukov, A.I. and G.I. Nazarova. 1991. Vertical migrations and feeding of 0-group silver hake (*Merluccius bilinearis*) on the Scotian Shelf, November 1985. NAFO Scientific Council Studies 15: 53-58.

Sutcliffe Jr., W.H. and P.F. Brodie. 1977. Whale distribution in Nova Scotia waters. Fisheries and Marine Service Technical Report 722.

3.13 Browns Bank

Location: Western Scotian Shelf (Figure 26).

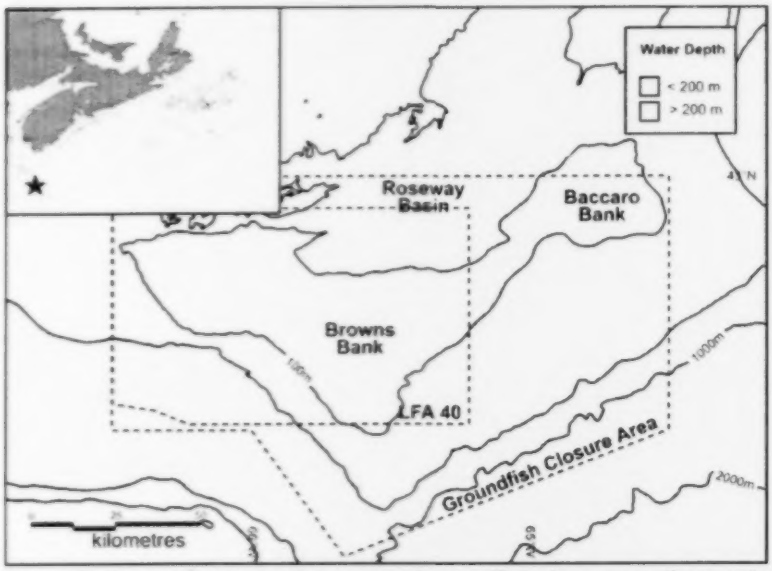


Figure 26. Browns Bank, showing seasonal groundfish closure area (large polygon) and lobster fishing closure (LFA 40, smaller polygon).

Current Status: Closed to groundfish fishing from 1 February to 15 June to protect spawning haddock; closed (year-round) to lobster fishing.

Human Activities: Fishing (especially for groundfish and scallops), shipping, submarine cable (one active, another proposed), research activities, MARLANT exercise areas F4 and F5.

Criteria (1): biological productivity, reproductive area
(2): significance (Scotian Shelf)

Importance:

- Highly productive for commercial species.
- Spawning area for haddock and other groundfish.
- Nursery area for haddock.
- Spawning and nursery area for lobster and scallops.

Remarks: Browns Bank is an important fishing area, probably the most important area open to the groundfish fishery in the study area. It is one of the better-studied areas of the Scotian Shelf. The bank appears to be a highly productive area. It is near the inshore area of southwest Nova Scotia that has regular upwelling (see e.g., Tee *et al.* 1993) and high levels of surface chlorophyll year-round (Harrison *et al.* 2000). The bank itself has a high rate of vertical diffusion,

yet there is a partial gyre that tends to retain particles (such as ichthyoplankton) on the bank. Loder *et al.* (1988) suggested that banks with short vertical diffusion times may recycle nutrients or transfer energy to other trophic levels more quickly. At the same time, the retention of fish and invertebrate eggs and larvae over the bank may hold them in preferred habitat or feeding conditions. The oceanographic features of the area have been found to be important in the feeding of larval haddock (see Wildish *et al.* 1989).

Browns Bank has been closed seasonally since 1970 to protect spawning haddock (Bishop and Brodie 1997). The timing of the closure has varied somewhat (Bishop and Brodie 1997) and the current closure is between 1 February and 15 June (DFO 2000). Some of the eggs spawned in the area remain there to develop to larvae, due to the partial gyre on the bank; others are carried by currents to the Bay of Fundy and inshore regions of southwest Nova Scotia (Shackell *et al.* 1999). The pebble-gravel or sandy-gravel bottom habitat appears to be important for juvenile haddock (Cargnelli *et al.* 1999) and changes in this habitat may have a negative impact on juvenile haddock survivability.

The lobster fishery on Browns Bank was closed in 1979 to protect what was believed to be an important spawning area (Pezzack *et al.* 1999). Lobster fishing occurs all around this area. Lobster landings from southwest Nova Scotia have generally been high throughout the 1990s (DFO 2001), consistent with high landings elsewhere in the Maritimes.

Kostylev *et al.* (2001) mapped the sea floor habitat of Browns Bank in detail using multibeam bathymetric data, other geoscience information, and photographs of the ocean floor. Six habitats were identified, two dominated by sand and four others dominated by gravel and various epifauna. This study is among the most detailed mapping of benthic habitat and associated species on the Scotian Shelf to date; however, relatively few species were involved because only photographic evidence was used. There is information available on other benthic fauna of Browns Bank from studies using grab samples (Wildish *et al.* 1989, 1990, 1992). Kostylev *et al.* (2001) noted that shallow sandy areas had little visible megafauna and attributed it to the more dynamic environment. In contrast, the gravel habitats with boulder-sized particles found in the central and eastern parts of the bank had a high diversity of epifauna. Different species were associated with different substrate. The bank has high concentrations of scallops in some areas of gravel bottom (see e.g., Kostylev *et al.* 2003) and appears to have good conditions for larval and juvenile scallops.

Much of Browns Bank has been fished by scallop vessels (Figure 27) in recent years and it is used by the groundfish fishery (Figure 28).

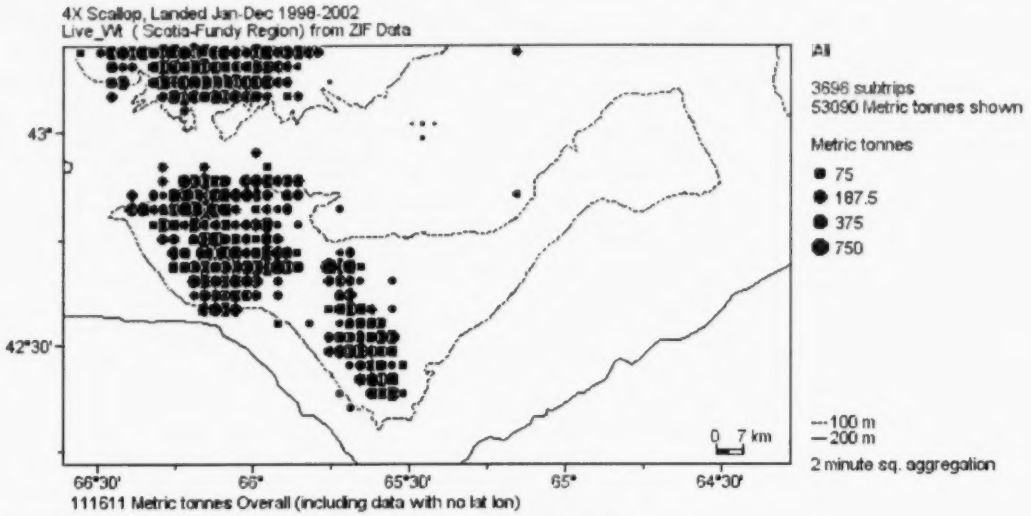


Figure 27. Scallop landings in the Browns Bank area, 1998-2002.

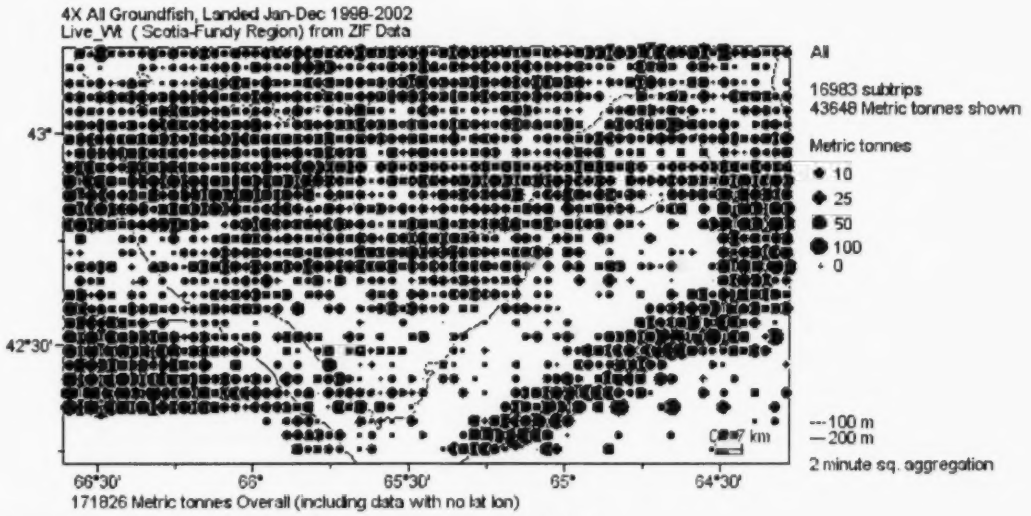


Figure 28. Groundfish landings, Browns Bank area, 1998-2002.

References (this section):

Bishop, C.A. and W.B. Brodie. 1997. Evaluation of offshore closed areas as a fisheries management tool, with emphasis on two case studies. NAFO SCR Doc. 97/32

Cargnelli, L.M., S.J. Griesbach, P.L. Berrien, W.W. Morse, and D.L. Johnson. 1999. Haddock, *Melanogrammus aeglefinus*, life history and habitat characteristics. Essential Fish Habitat Source Document. NOAA Technical Memorandum, NMFS-NE-128.

DFO (Fisheries and Oceans Canada). 2000. Groundfish: Integrated Fisheries Management Plan, Scotia-Fundy Fisheries, Maritimes Region. April 1, 2000 – March 31, 2002. Internet document. <http://www.mar.dfo-mpo.gc.ca/fisheries/res/imp/2000grndfish.htm> Accessed 12 August 2003.

DFO (Fisheries and Oceans Canada). 2001. Southwest Nova Scotia Lobster (Lobster Fishing Area 34). DFO Science Stock Status Report C3-62 (2001).

Harrison, G., B. Petrie, and T. Platt. 2000. Chlorophyll climatology of the continental shelf off Nova Scotia. Poster presented at the American Society of Limnology and Oceanography 2000 Ocean Sciences Meeting. San Antonio, Texas, 24-28 January 2000.

Kostylev, V.E., R.C. Courtney, G. Robert, and B.J. Todd. 2003. Stock evaluation of giant scallop (*Placopecten magellanicus*) using high-resolution acoustics for seabed mapping. Fisheries Research 60: 479-492.

Kostylev, V.E., B.J. Todd, G.B.J. Fader, R.C. Courtney, G.D.M. Cameron, and R.A. Pickrill. 2001. Benthic habitat mapping on the Scotian Shelf based on multibeam bathymetry, surficial geology and sea floor photographs. Marine Ecology Progress Series 219: 121-137.

Loder, J.W., C.K. Ross, and P.C. Smith. 1988. A space- and time-scale characterization of circulation and mixing over submarine banks, with application to the northwestern Atlantic continental shelf. Canadian Journal of Fisheries and Aquatic Sciences 45: 1860-1885.

Pezzack, D.S., P. Lawton, I.M. Gutt, D.R. Duggan, D.A. Robichaud, and M.B. Strong. 1999. The American lobster *Homarus americanus* fishery off of south-western Nova Scotia (Lobster Fishing Area 34). Canadian Stock Assessment Secretariat Research Document 99/32.

Shackell, N.L., K.T. Frank, B. Petrie, D. Brickman, and J. Shore. 1999. Dispersal of early life stage haddock (*Melanogrammus aeglefinus*) as inferred from the spatial distribution and variability in length-at-age of juveniles. Canadian Journal of Fisheries and Aquatic Sciences 56: 2350-2361.

Tee, K.T., P.C. Smith, and D. LeFaivre. 1993. Topographic upwelling off southwest Nova Scotia. Journal of Physical Oceanography 23: 1703-1726.

Wildish, D.J., A.J. Wilson and B. Frost. 1989. Benthic macrofaunal production of Browns Bank. Canadian Journal of Fisheries and Aquatic Sciences 46: 584-590.

Wildish, D.J., B. Frost and A.J. Wilson. 1990. Stereographic analysis of the marine, sublittoral sediment-water interface. Canadian Technical Report of Fisheries and Aquatic Sciences 1726.

Wildish, D.J., A.J. Wilson, and B. Frost. 1992. Benthic boundary layer macrofauna of Browns Bank, Northwest Atlantic, as potential prey of juvenile benthic fish. Canadian Journal of Fisheries and Aquatic Sciences 49: 91-98.

3.14 Northeast Channel (Romey's Peak area)

Location: Mouth of Northeast Channel between Browns and Georges Bank (Figure 29).

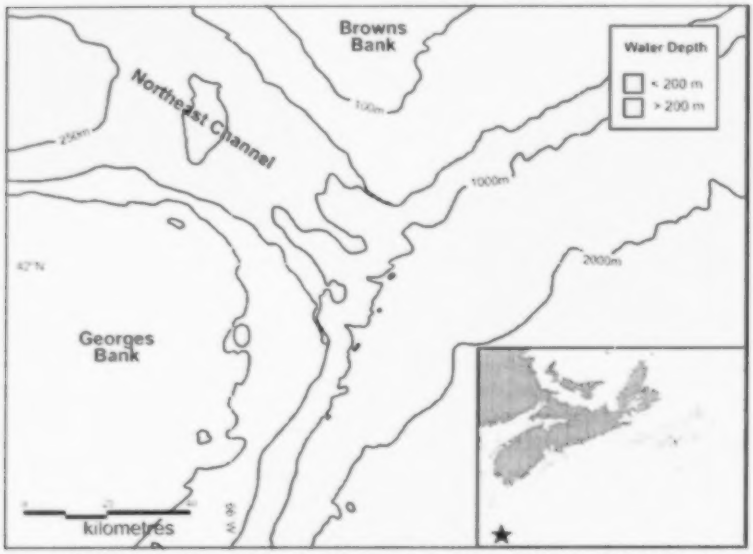


Figure 29. The Northeast Channel. Romey's Peak is at the mouth of the channel.

Current Status: Part of this area has been closed to fishing using bottom gear to protect coral, particularly colonies of *Primnoa resedaeformis*. There is a moratorium on petroleum exploration and development in this area (part of Georges Bank moratorium).

Human Activities: fishing, shipping, research activities, submarine cable (abandoned), partially in MARLANT exercise area F4

Criteria (1): rare/unique habitat and habitat for rare species
(2): fragility/sensitivity

Importance:

- Highest known concentration off Nova Scotia of the deep sea gorgonian coral *Primnoa resedaeformis*. Large gorgonian corals have a wide range but relatively patchy distribution in Atlantic Canada.
- Other species are associated with coral species, resulting in rich communities.
- Corals can be broken off by fishing gear or other heavy objects and may be vulnerable to sedimentation.
- The area has a high value for scientific research.

Remarks: "Large tree corals" were noted in this area by halibut fishermen of the nineteenth century (Collins and Rathbun 1887). Interviews with fishermen in the late 1990s and records from museum collections highlighted the Northeast Channel as an area important for large

gorgonian corals (Breeze *et al.* 1997). Reports from fisheries observers and scientific research in the area have provided further evidence of the area's importance, particularly for the gorgonian *Primnoa resedaeformis* (MacIsaac *et al.* 2001, Gass 2002, Mortensen *et al.* 2002).

The coral *Primnoa resedaeformis* is found attached to gravel sediments in the area, particular rocks and boulders (MacIsaac *et al.* 2001, Mortensen *et al.* 2002). The Northeast Channel is known for strong tides and high current activity and it is likely that the strong currents provide good feeding conditions for the corals.

Efforts to protect the area from damage caused by fishing gear were initiated by the Canadian Ocean Habitat Protection Society (COHPS) and the Ecology Action Centre (Willison *et al.* 2002). The scientific program on corals carried out by DFO, Dalhousie University, and other agencies provided images of concentrations of *P. resedaeformis* in the area, evidence of their vulnerability to disturbance by bottom fishing gear (see Mortensen *et al.* 2002), and provided more refined information on their distribution in the area. Work on species associated with coral habitats is on-going.

In 2002, DFO placed fishing restrictions on part of the area of known coral habitat. This coral conservation area (CCA) included the area with the highest concentration of corals. In most of the CCA, bottom fisheries are prohibited (Figure 30). A small portion of the area is open to longline vessels that carry fisheries observers (the size of this area was reduced in 2003). The closure provides an opportunity for scientists to observe benthic habitat in the closed area and compare it with nearby areas that remain open to fishing. Gass (2002) expressed concern that the closure does not protect the area with the greatest fishing activity, and thus the most vulnerable corals.

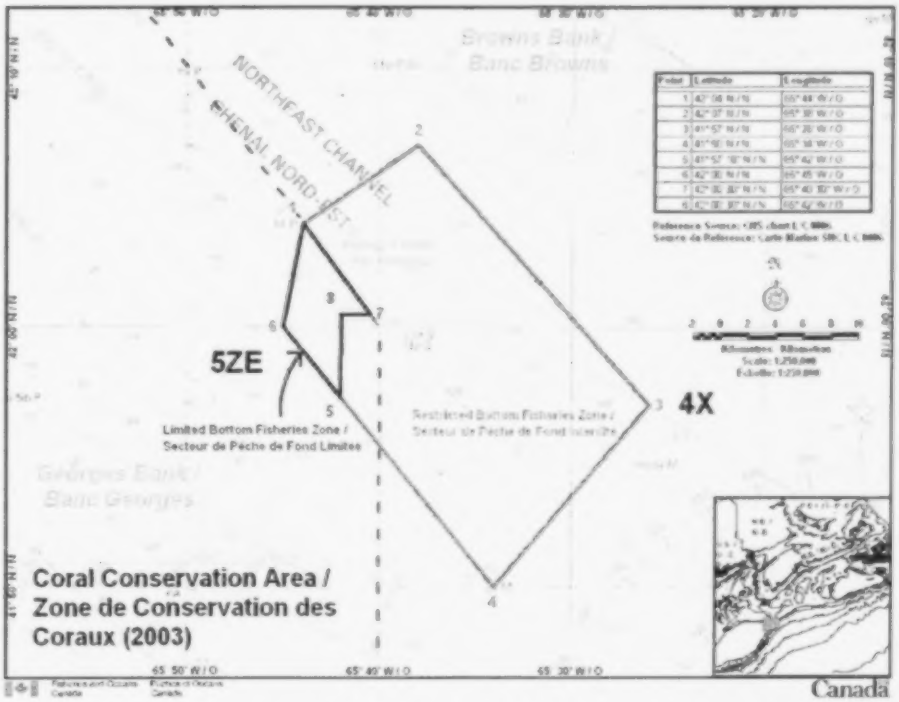


Figure 30. Area of the Northeast Channel with limited bottom fisheries and restricted area where bottom fisheries are not allowed (coordinates for 2003). The whole area is known as the Coral Conservation Area (map used with permission of the Oceans and Coastal Management Division, Maritimes Region, DFO).

References (this section):

Breeze, H., D.S. Davis, and M. Butler. 1997. Distribution and status of deep sea corals off Nova Scotia. Marine Issues Committee Special Publication Number 1. Halifax, NS: Ecology Action Centre.

Collins, J.W. and R. Rathbun. 1887. The sea fishing grounds of the eastern coast of North American from Greenland to Mexico. In: G.B. Goode. The Fisheries and Fishery Industries of the United States. Section III: The Fishing Grounds of North America with Forty-Nine Charts. Washington: Government Printing Office. pp. 5-78.

Gass, S. E. 2002. An assessment of the distribution and status of deep sea corals in Atlantic Canada by using both scientific and local forms of knowledge. Master of Environmental Studies thesis. Dalhousie University, Halifax, NS.

MacIsaac, K., C. Bourbonnais, E. Kenchington, D. Gordon Jr. and S. Gass. 2001. Observations on the occurrence and habitat preference of corals in Atlantic Canada. In J.H.M Willison, J. Hall, S. Gass, E. Kenchington, M. Butler, and P. Doherty, eds. Proceedings of the First International Symposium on Deep Sea Corals. Halifax, NS: Ecology Action Centre and Nova Scotia Museum. pp. 58-75.

Mortensen, P.B., L. Buhl-Mortensen, D.C. Gordon Jr., G.B.J. Fader, D.L. McKeown, and D.G. Fenton. in press. Effects of Fisheries on Deep-water Gorgonian Corals in the Northeast Channel, Nova Scotia (Canada). Presented at the Symposium on the Effects of Fishing Activities on Benthic Habitats: Linking Geology, Biology, Socioeconomics, and Management, November 12-14, 2002, Tampa, FL.

Willison, J.H.M., D.P. Jones and S. Atwood. 2002. Deep sea corals and marine protected areas in Nova Scotia. In: S. Bondrup-Nielsen *et al.*, eds. Managing Protected Areas in a Changing World. Wolfville, NS: SAMPAA. pp. 1157-1163.

3.15 Roseway Basin

Location: North of Browns and Baccaro Banks (Figure 31).

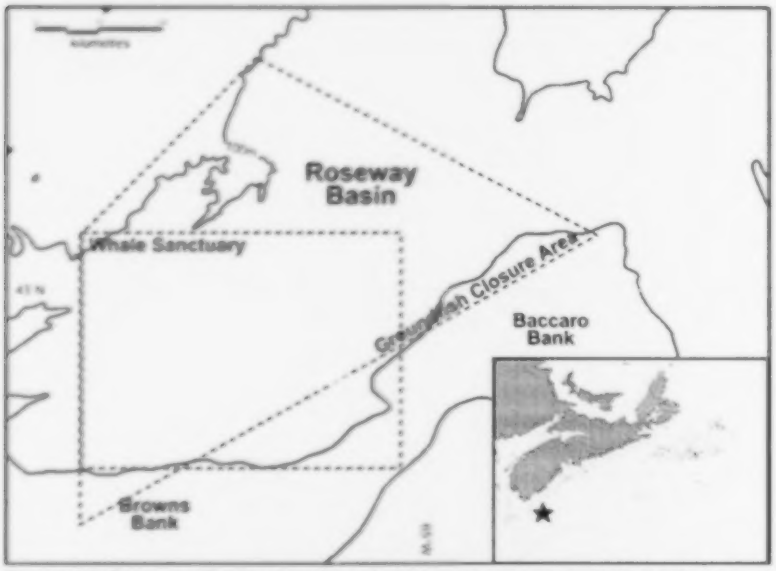


Figure 31. Roseway Basin, showing whale sanctuary (rectangle) and the area closed to small-meshed gear, also known as the "Bowtie" (large trapezoid). Co-ordinates of the bowtie are from the 2000-2002 Groundfish Integrated Fisheries Management Plan (DFO 2000).

Current Status: Whale Sanctuary (Fisheries and Oceans Canada), closed to small-meshed fishing gear to protect juvenile redfish.

Human Activities: Fishing (limited), shipping, submarine cable, research activities, MARLANT Exercise Areas F3 and F4.

Criteria (1): biological productivity, reproductive area, habitat for endangered/threatened species
(2): significance (Scotian Shelf and global)

Importance:

- The area off Cape Sable Island has high levels of primary productivity.
- Roseway Basin is a summer feeding ground for the endangered North Atlantic right whale and other copepod-feeding whales are likely to be found there.
- It is called a right whale conservation area in the Right Whale Recovery Plan and declared a Whale Sanctuary in notices to mariners.
- It has been identified as an area with high concentrations of juvenile redfish.

Remarks: The North Atlantic right whale is one of the most highly endangered large whale species, with a population size estimated to be between 300 and 350 animals in 1998 (Right

Whale Recovery Team 2000). Roseway Basin is a habitat of importance for the whale and is used as a summer to fall (approximately June to November) feeding area (Right Whale Recovery Team 2000). It seems to have been less used in the mid-1990s, but recent surveys have shown that the basin is again a high-use area (see Waring *et al.* 2001, Clapham and Wenzel 2002). Roseway Basin was designated a seasonal whale sanctuary (right whale conservation area) by DFO in 1993 (see Figure 31). The Canadian Right Whale Implementation Team is preparing a proposal to the International Maritime Organization to designate Roseway Basin as an Area to be Avoided (ATBA) by shipping.

The Canadian Right Whale Recovery Plan (Right Whale Recovery Team 2000) and U.S. Marine Mammal Stock Status Reports (Waring *et al.* 2001) provide a good overview of the status of this population. Because of the population's very low numbers, there has been a great deal of effort to reduce mortality of right whales. The greatest threats to the animals are entanglement in fishing gear and ship strikes. Knowlton *et al.* (2001 cited in Waring *et al.* 2001) estimated that between 10 and 28 percent of the population was involved in entanglements each year. Not all entanglements are fatal, but entanglements result in both direct and indirect mortality, as towing fishing gear can be a chronic stressor for the animal (Waring *et al.* 2001). For example, whales tangled in lines but still mobile may have less success in feeding. Ship strikes are a major cause of mortality (Waring *et al.* 2001). Right whales do not appear to be very successful in avoiding ships. It has been suggested that high frequency ship noise does not fall within their hearing range (Terhune and Verboom 1999).

Roseway Basin is part of a Natural Area of Canadian Significance (NACS) identified by P. Lane and Associates (1992). The NACS encompasses both the basin and an area off Cape Sable Island that has a persistent upwelling feature (see e.g., Tee *et al.* 1993) and was noted as an area of high primary productivity (P. Lane and Associates 1992). Satellite images show high levels of surface chlorophyll in this area year-round (Harrison *et al.* 2000). This area of high primary productivity influences both Roseway Basin and Browns Bank.

The bowtie area north of Browns and Baccaro Banks is closed to small mesh gear (less than 130 millimetre mesh size) to protect juvenile redfish. The initial closure began in 1995 with somewhat different boundaries. The boundaries were redefined in 1998 (Branton 1999). Genetic research has established that most redfish in the area are the species *Sebastes fasciatus* (Acadian redfish) (Branton 1999). Juvenile redfish from the western Scotian Shelf stock appear to be concentrated in Roseway Basin and perhaps Crowell and Jordan Basins in the Gulf of Maine; however, there is some evidence that the Gulf of Maine is a separate stock (see Branton 1999). Adults and juveniles prefer fine-grained bottoms (silt or mud) or the unsorted sediments known as Scotian Shelf drift (gravel, silts, clay and boulders). They are rarely found in areas of sand (Pikanowski *et al.* 1999). Larvae eat copepod eggs and larvae. Juveniles eat copepods, euphausiids, mysids and fish, depending on size (Pikanowski 1999). The affinity of juvenile redfish for the Bowtie area should be looked at in more detail.

References:

Branton, R. 1999. Update on the status of Unit 3 Redfish. Canadian Stock Assessment Secretariat Research Document 99/152.

Clapham, P. and F. Wenzel. 2002. Cruise Report, R/V Delaware II. Cruise No. DE 02-07. Large Whale Survey. 12 September 2002.

DFO (Fisheries and Oceans Canada). 2000. Groundfish: Integrated Fisheries Management Plan, Scotia-Fundy Fisheries, Maritimes Region. April 1, 2000 – March 31, 2002. Internet document <http://www.mar.dfo-mpo.gc.ca/fisheries/res/imp/2000grndfish.htm> Accessed 12 August 2003.

Harrison, G., B. Petrie, and T. Platt. 2000. Chlorophyll climatology of the continental shelf off Nova Scotia. Poster presented at the American Society of Limnology and Oceanography 2000 Ocean Sciences Meeting. San Antonio, Texas, 24-28 January 2000.

Knowlton, A.R., M.K. Marx, H.M. Pettis, P.K. Hamilton, and S.D. Kraus. 2001. Scarification analysis of North Atlantic right whales *(Eubalaena glacialis)*: monitoring rates of entanglement interaction. Report to the National Marine Fisheries Service, available from New England Aquarium, Central Wharf, Boston, MA 02110. Cited in Waring *et al.* 2001.

P. Lane and Associates. 1992. A Study to Identify Marine Natural Areas of Canadian Significance in the Scotian Shelf Marine Region. Project E-363. Prepared for Canadian Parks Service, Environment Canada.

Pikanowski, R.A., W.W. Morse, P.L. Berrien, D.L. Johnson, and D.G. McMillan. 1999. Redfish, *Sebastes* spp., Life History and Habitat Characteristics. Essential Fish Habitat Source Document. NOAA Technical Memorandum NMFS-NE-132.

Right Whale Recovery Team. 2000. Canadian North Atlantic Right Whale Recovery Plan. World Wildlife Fund Canada and the Department of Fisheries and Oceans.

Tee, K.T., P.C. Smith, and D. LeFaivre. 1993. Topographic upwelling off southwest Nova Scotia. Journal of Physical Oceanography 23: 1703-1726.

Terhune, J.M. and W.C. Verboom. 1999. Right whales and ship noises. Letter. Marine Mammal Science 15: 256-258.

Waring, G.T., J.M. Quintal, and S.L. Swartz, eds. 2001. U.S. Atlantic and Gulf of Mexico Marine Mammals Stock Assessments – 2001. National Marine Fisheries Service. NOAA Technical Memorandum NMFS-NE-168.

3.16 Scallop Fishing Area 29, West of Baccaro

Location: Off southwest Nova Scotia, by German Bank (Figure 32).

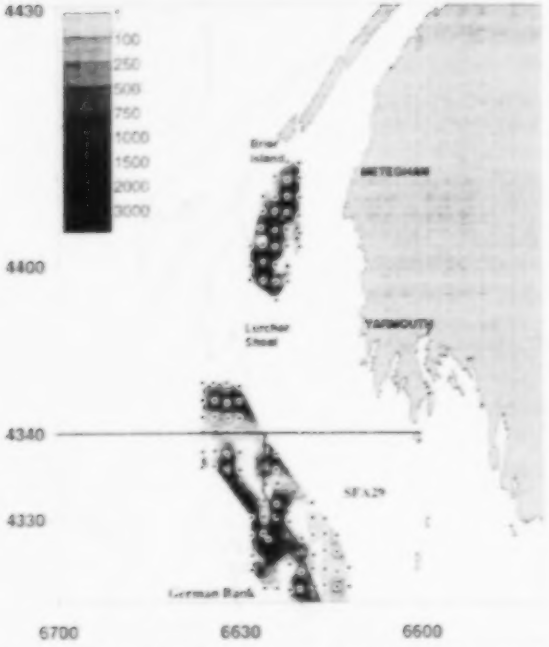


Figure 32. Part of Scallop Fishing Area 29 and German Bank, showing distribution of scallops found during a 1992 stock survey (from Kenchington and Lundy 1996). Circles show tow locations and shades of grey refer to numbers of scallops per tow.

Current Status: No management measures particular to the area.

Human Activities: Fishing, shipping, MARLANT exercise area F3.

Criteria (1): reproductive area

Importance:

- Areas with high densities of scallops may be important scallop broodstock areas, seeding areas upstream.
- The area has dense concentrations of lobster larvae.

Remarks: The far western portion of Scallop Fishing Area 29 (SFA 29) and an adjacent part of German Bank were identified in Kenchington and Lundy (1996) as an important scallop broodstock area. They suggested that the scallop closure that existed in SFA 29 at the time should continue. However, they also found that German Bank was more suitable as a broodstock area, as only the westernmost portion of SFA 29, next to German Bank, was important for areas upstream.

SFA 29 is a large area extending from waters off Yarmouth to Cape Breton. There is an extensive fishery occurring in inshore areas east of Baccaro (Smith and Lundy 2002). The area west of Baccaro has been managed somewhat differently and it is this part of SFA 29 that was examined for broodstock potential. It was opened to fishing from 1996 to 1998, then closed in 1999 and 2000 following criticism from the Auditor General that DFO had opened a broodstock area that seeded other scallop beds (Smith and Lundy 2002). Smith and Lundy (2002) note that the portrayal of this area as a broodstock area has been somewhat misinterpreted, as the SFA 29 portion of the recommended closure gained elevated importance in later reports and the German Bank component was ignored. They also note that it was only a small portion of SFA 29 that was deemed important as a broodstock area. Recent surveys have found that scallop beds are widely distributed in SFA 29 west of Baccaro. The known distribution of scallops in the area is broader than when the initial closure recommendation was made. Although Smith and Lundy (2002) explain how the initial recommendation was misinterpreted, they do not clearly state recommendations for the area and its importance is not clear. SFA 29 has again been opened to scallop fishing, with a small area just south of Cape Sable Island closed (DFO 2003). At this time, this area does not appear to rank any higher than other areas with concentrations of scallops that could also be broodstock areas.

There are dense concentrations of settling stage larval lobsters in this area (Harding and Trites 1988). The nearby coastal area of Lobster Bay is an important lobster fishing area. 1998-1999 and 1999-2000 landings in LFA34 (the lobster fishing area which includes Lobster Bay and German Bank) were the highest ever recorded in this fishery, which has records dating back to the 1890s (DFO 2001).

References (this section):

DFO (Fisheries and Oceans Canada). 2001. Southwest Nova Scotia Lobster (Lobster Fishing Area 34). DFO Science Stock Status Report C3-62.

DFO (Fisheries and Oceans Canada). 2003. Scallop Production Areas (SPAs) in the Bay of Fundy. DFO Science Stock Status Report 2003/025.

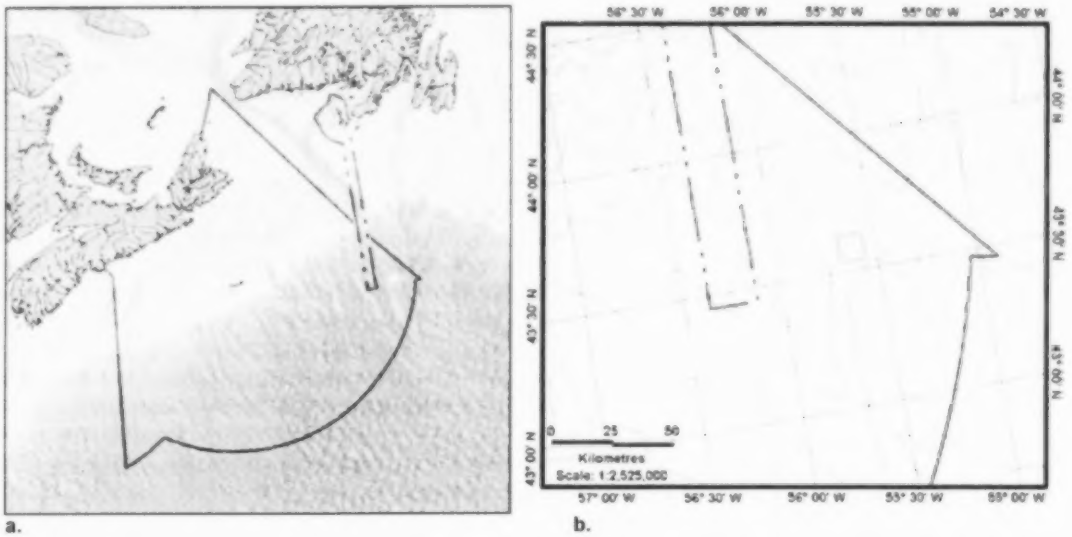
Harding, G.C. and R.W. Trites. 1988. Dispersal of *Homarus americanus* larvae in the Gulf of Maine from Browns Bank. Canadian Journal of Fisheries and Aquatic Sciences 45: 416-425.

Kenchington, E. and M.J. Lundy. 1996. An assessment of areas for scallop broodstock protection in the approaches to the Bay of Fundy. DFO Atlantic Fisheries Research Document 96/13.

Smith, S.J. and M.J. Lundy. 2002. A brief history of scallop fishing in Scallop Fishing Area 29 and an evaluation of a fishery in 2002. Canadian Stock Assessment Secretariat Research Document 2002/079.

3.17 Cold seep communities, Eastern Valley, Laurentian Fan

Location: Deep waters (3840-3890 m) of the Laurentian Fan (Figure 33).



a. b.

Figure 33. Location of potential cold seep communities in Laurentian Fan area (yellow square) in relation to Atlantic Canada (a.) and latitude/longitude (b.). The red line outlines Canada's Exclusive Economic Zone. The yellow square represents the general area of the communities. The actual extent of the communities is much smaller.

Current Status: No management regime particular to the area. Fisheries for cod and haddock in 4VSW closed (but unlikely to occur in these deep waters).

Human Activities: Pelagic fisheries, Shipping.

Criteria (1): biodiversity, rare/unique habitat and habitat for rare species (likely naturalness as well)
(2): significance (Scotian Shelf and Slope, perhaps Northwest Atlantic)

Importance:

- No other potential chemosynthetic cold seep communities are known from Atlantic Canada.
- Some of the species found there are likely to be found only in other cold seep communities.
- A new family of polychaetes was identified from the area.
- The area has high value for scientific research.

Remarks: Sulfide or methane-rich fluids seep from some areas of the ocean floor. In some areas, these seeps are associated with high temperatures and deposits of minerals (hydrothermal vents), while in others, they are not (cold seeps). Specialized communities of

organisms are associated with both hydrothermal vent and cold seep areas. These communities include chemosynthetic bacteria that are able to convert sulphur compounds to energy, organisms with symbiotic chemosynthetic bacteria, and organisms that prey on the chemosynthetic bacteria.

In 1987, scientists conducting geological surveys of the Eastern Valley of the Laurentian Fan found four large, dense biological communities at depths between 3840 and 3890 metres (Mayer *et al.* 1988). The communities consisted of vesicomyid and thyasirid clams, gastropods, galatheid crabs and other organisms. The fauna was significantly different and much more abundant than the fauna observed on other dives in the area. Because the researchers were not properly equipped to undertake a biological survey, few samples were taken. However, from the few samples, a new family of polychaete was identified.

The researchers noted that the composition of these communities resembled that of hydrothermal vent areas (at the time, there had been little research carried out on cold seep communities). All known vesicomyid bivalves have specialized tissue with carbon-fixing, sulfide-oxidizing endosymbiotic bacteria and are found in sulfide-rich areas (Goffredi and Barry 2002). These bacteria provide organic materials to their hosts. As well as the evidence provided by the presence of the vesicomyid bivalves, the huge, localized biomass suggested to the researchers that these communities were being sustained by chemosynthetic processes. The researchers noted that these communities were found near the crests of gravel waves. By disturbing the sediments, the 1929 Grand Banks earthquake may have created appropriate conditions for this community (Mayer *et al.* 1988). No other potential cold seep communities in Atlantic Canada are known.

There has been no further research on the benthic communities in this area and no similar communities have been discovered in the Laurentian Fan area (Piper pers. comm).

References (this section):

Goffredi, S.K. and J.P. Barry. 2002. Species-specific variation in sulfide physiology between closely related Vesicomyid clams. Marine Ecology Progress Series 225: 227-238.

Mayer, L.A., A.N. Shor, J. Hughes Clarke and D.J.W. Piper. 1988. Dense biological communities at 3850 m on the Laurentian Fan and their relationship to the deposits of the 1929 Grand Banks earthquake. Deep-Sea Research 35: 1235-1246.

Personal communications:

David Piper, Research Scientist, Geological Survey of Canada–Atlantic, Natural Resources Canada. E-mail to author. 27 November 2002.

3.18 LaHave Bank

Location: Outer part of the western shelf (Figure 34).

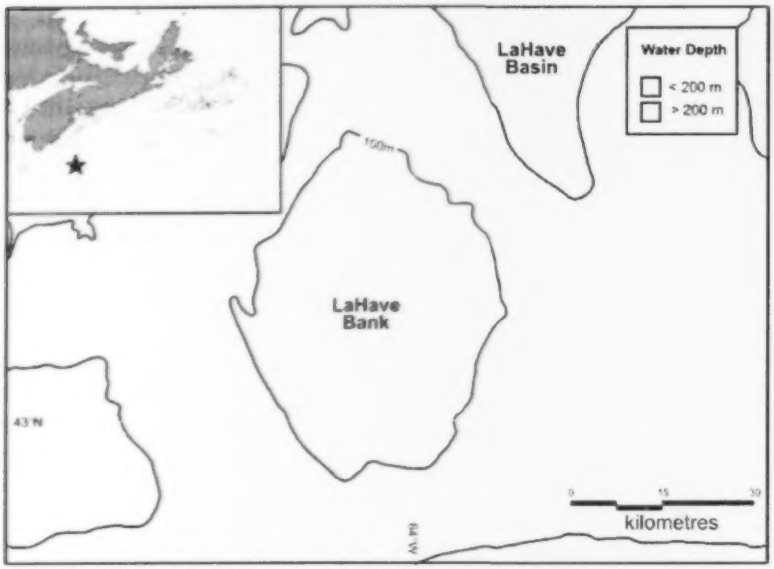


Figure 34. LaHave Bank

Current Status: No particular management measures for the area.

Human Activities: fishing, submarine cables, shipping, MARLANT exercise areas G4 and C3.

Criteria (1): naturalness

Importance:

- Suggested as an area with undisturbed bottom habitats.

Remarks: Most bottom areas of the Scotian Shelf have been used for fishing using bottom gear at some point in recent years. However, areas with dense distributions of large boulders are thought to have restricted bottom fishing activity, particularly activity using mobile gear. Fader in P. Lane and Associates (1992) suggested that much of LaHave Bank would have concentrations of large boulders and these areas would be "unique, undisturbed ecological habitats." These habitats may be appropriate scientific reference areas. They may also have species that are not found in disturbed habitats of the Scotian Shelf.

LaHave Bank appears to be covered with fishing activity when maps showing the entire Scotian Shelf are examined (Figures 37 and 38. These maps are discussed in more detail in section 3.19). The Scotian Shelf maps have a 5-minute aggregation of activity as this aggregation was deemed appropriate for the size of the map and area shown. When LaHave Bank was looked at by itself, with no aggregation of activity, presence/absence data for fishing effort in the area indicated that most of LaHave Bank has been fished for groundfish or scallop (Figures 35 and 36). There are some small areas of LaHave Bank that have not been used recently by either groundfish or scallop fishermen. All gears were selected in an effort to find

areas truly undisturbed by any bottom gear. However, there may be areas of fishing activity that are less highly used or used by fixed gear vessels only that could potentially represent a more natural environment.

Recovery time for benthic habitats after trawling or dredging is different in different environments. In a summary of the literature to date, the National Research Council (2002) stated that sandy bottoms in energetic environments have been hypothesized as having shorter recovery times, while findings to date suggest that more stable and complex habitats, such as gravel and biogenic habitats, have longer recovery times. In some cases, recovery may not occur. Instead, the ecosystem may shift to an alternate state (National Research Council 2002).

There is relatively little information about LaHave Bank. The surficial geology is the gravel phase of the unit known as Sable Island sand and gravel (which includes gravel from pebble to boulder size) (Drapeau and King 1972). The bank does not appear to be an important spawning area for groundfish as compared with the other large outer banks of the Scotian Shelf. However, there have been few research activities on this bank. The potential occurrence of undisturbed habitats on LaHave Bank and the importance of those habitats for the Scotian Shelf warrants further investigation. It is noteworthy that some larger areas of the Scotian Shelf appear to be less impacted by fishing activity, at least in recent years (see section 3.19). These areas may be less disturbed by human activity than LaHave Bank. The bank was given a separate profile because it was identified in the literature as potentially having undisturbed habitats, and it would not have been identified using the method used to identify the areas discussed in the next section.

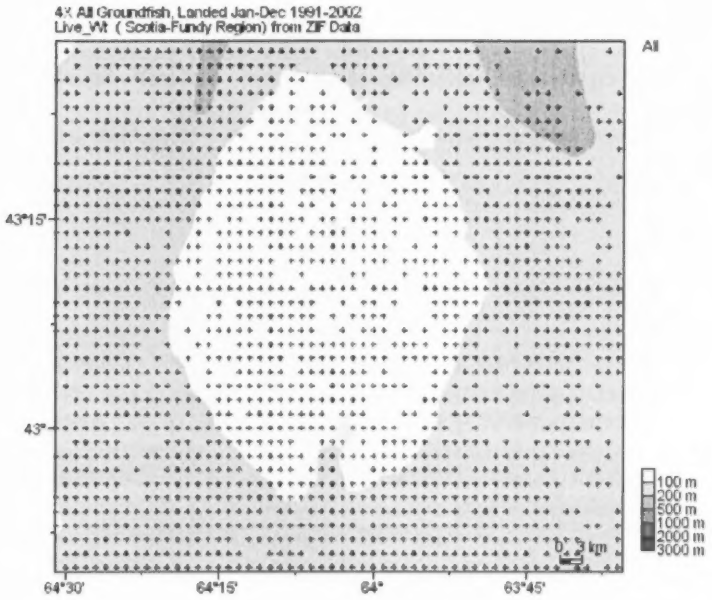


Figure 35. Areas of LaHave Bank with groundfish landings, 1991-2002. No aggregation. All gears are selected; some reports may be landings of groundfish caught by non-bottom gears.

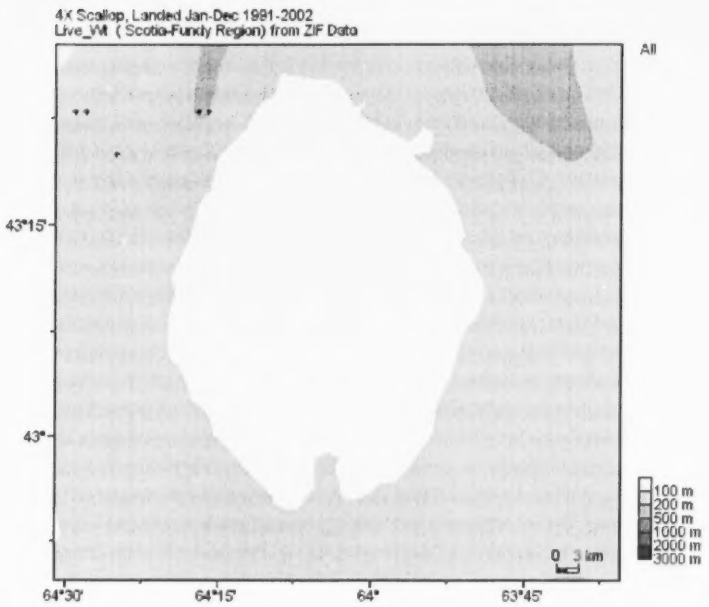


Figure 36. Areas of LaHave Bank with scallop landings, 1991-2002. No aggregation.

References (this section):

Drapeau, G. and L.H. King. 1972. Surficial geology of the Yarmouth-Browns Bank map area. Geological Survey of Canada Paper 72-24.

National Research Council. Committee on Ecosystem Effects of Fishing. 2002. *Effects of Trawling and Dredging on Seafloor Habitat.* Washington, DC: National Academy Press.

P. Lane and Associates. 1992. A Study to Identify Marine Natural Areas of Canadian Significance in the Scotian Shelf Marine Region. Project E-363. Prepared for Canadian Parks Service, Environment Canada.

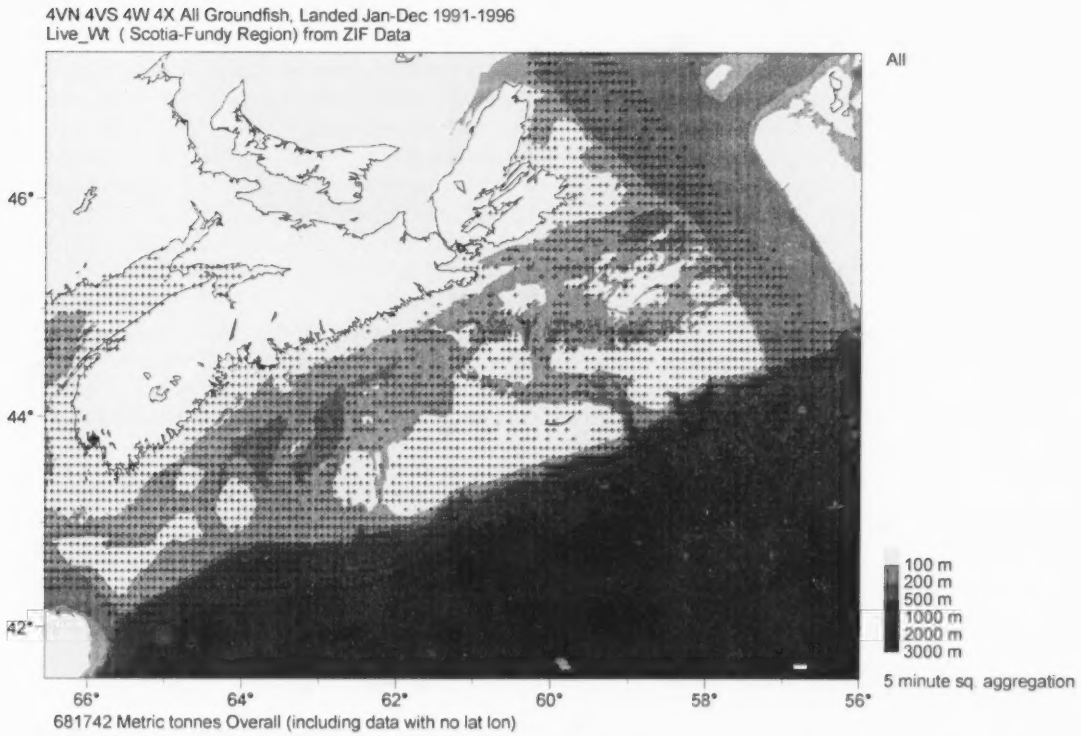


Figure 37. Areas with groundfish landings, 1991-1996, grouped by 5 minute squares. All gears are selected; some areas may potentially show landings of groundfish caught by non-bottom gears.

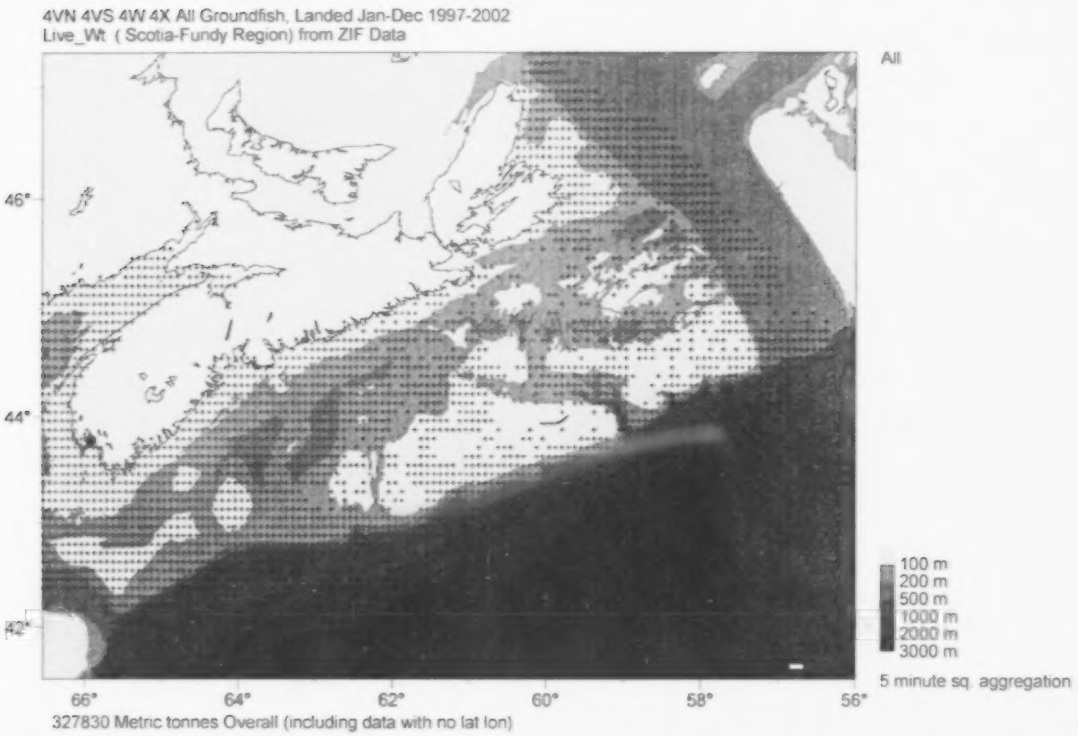


Figure 38. Areas with groundfish landings, 1997-2002, grouped by 5 minute squares. All gears are selected; some areas may potentially show landings of groundfish caught by non-bottom gears.

3.19 Areas with Very Little Bottom Fishing Activity

These areas were selected for this report using a somewhat different methodology than that used to selecting the other areas profiled. Please refer to section 2.4 for more information on the their inclusion.

Areas with very little bottom fishing activity represent less disturbed and potentially more "natural" habitats.[9] As discussed in the previous section on LaHave Bank, recovery time for benthic habitats after trawling or dredging is different in different environments (see National Research Council 2002). Biogenic habitats, particularly those habitats with large, long-lived attached fauna, may exhibit high mortalities after a single disturbance and have very slow recovery rates from disturbance (see National Research Council 2002).

Maps of fishing activity on the Scotian Shelf were examined for areas that indicated no bottom fishing activity (Figures 37 and 38, above). Fishing activity that landed groundfish was selected, as gears that catch those species would be likely to impact bottom habitats (other fisheries also affect bottom habitats and were looked at in more detail in the individual profiles). The focus of this exercise was on the continental shelf, which is more heavily fished by bottom gear. Much of the slope has not been impacted by bottom fishing activity and the slope in general may represent a more natural (although very different) environment than that of the shelf.

There is fishing activity in most areas of the Scotian Shelf. Presence/absence mapping was used to find areas where groundfish have not been caught in recent years (1991-2002). This method of mapping does not indicate the amount of effort at each data point. There is a high number of subtrips in the commercial landings database and there is known to be some misreporting or misentering of data. However, considering the high number of subtrips in the database, it is more likely that an area will be falsely indicated as fished rather than left blank. Thus, it is noteworthy that some areas have no reported catches of groundfish. Three of these areas are profiled below. These profiles include presence/absence maps showing location of catches of several species that are caught using bottom fishing gear: groundfish, shrimp, scallops, surf clams, snow crab, Jonah crab and red crab.

Two of the areas, the areas by Canso and Misaine Banks, did not appear to be ecologically significant areas in the initial scoping exercise (Appendix 1) and relatively little is known about them. There have been few dedicated studies of these areas of the Scotian Shelf and there is relatively little human activity in these areas.

A full assessment of these areas should consider the full range of human activities that occur or have occurred in the area. It should also consider the degree of naturalness relative to each other and the sensitivity of the environment, such as potential recovery time after disturbance.

References (this Section)

National Research Council. Committee on Ecosystem Effects of Fishing. 2002. Effects of Trawling and Dredging on Seafloor Habitat. Washington, DC: National Academy Press.

[9] Although only bottom fishing activity was looked at as an indicator of "naturalness," other human activities, seafloor dredging, deposits of contaminants, introduction of exotic species, and pelagic fisheries, can significantly change ecosystems. Because there is relatively good information on bottom fishing activities, it was relatively easy to use as an indicator of naturalness. Other human activities and levels of contaminants should also be looked at for the areas profiled here.

3.19.1 Canso Bank and nearby areas

Location: Inner shelf, off Canso, Nova Scotia.

Current Status: Closed to fisheries for cod and haddock since 1993 (part of 4VSW closure).

Human Activities: Fisheries (shrimp, snow crab), shipping, submarine cables (abandoned).

Criteria (1): Naturalness, potentially other criteria (such as biodiversity)

Importance:

- Unknown. Few studies of the area.

Remarks: Much of the area has not been fished for groundfish in the 1990-2001 period (Figure 39). Other fisheries occur there: there are fisheries for shrimp (Figure 40) and snow crab (Figure 41) in deep waters in the area. There is a lobster fishery in nearshore areas. It is not a scallop, surf clam, red crab or Jonah crab fishing area.

Although this area shows little recent groundfish activity, it may have been fished more heavily in the past. Canso Bank is about 30 kilometres from the town of Canso, which began as one of the earliest French fishing stations in North America and has been a prominent fishing port throughout its history.

There have been few studies of the area, although nearby Chedabucto Bay has been studied extensively (see e.g., McCracken 1979, Harding *et al.* 1983). Maps in a study of marine fish diversity on the Scotian Shelf indicate this area rates high in species richness (Shackell and Frank 2003).

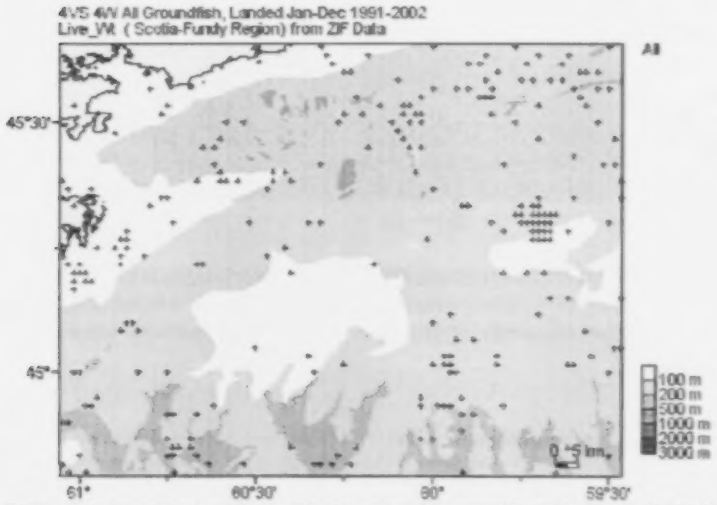


Figure 39. Areas in the Canso Bank area with groundfish landings, 1991-2002. No aggregation. All gears are selected; some reports may be landings of groundfish caught with shrimp gear or non-bottom gear, particularly since the area has been closed to directed fishing of groundfish since 1993.

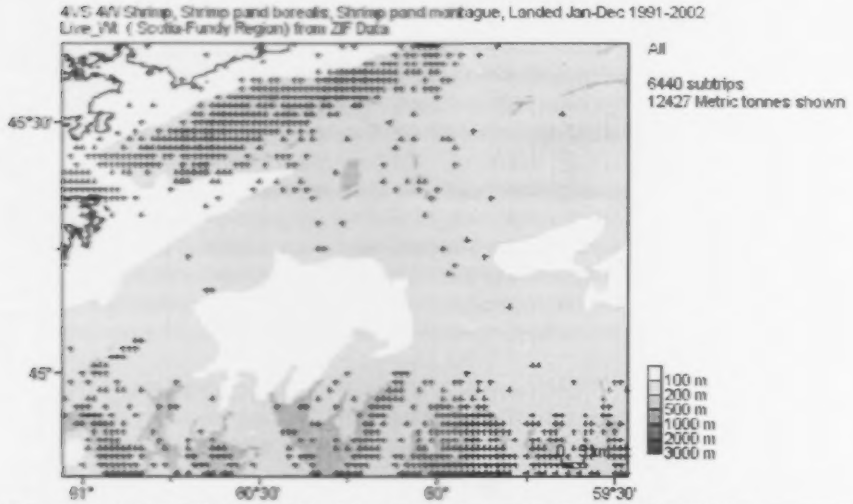


Figure 40. Areas in the Canso Bank area with shrimp landings, 1991-2002. No aggregation.

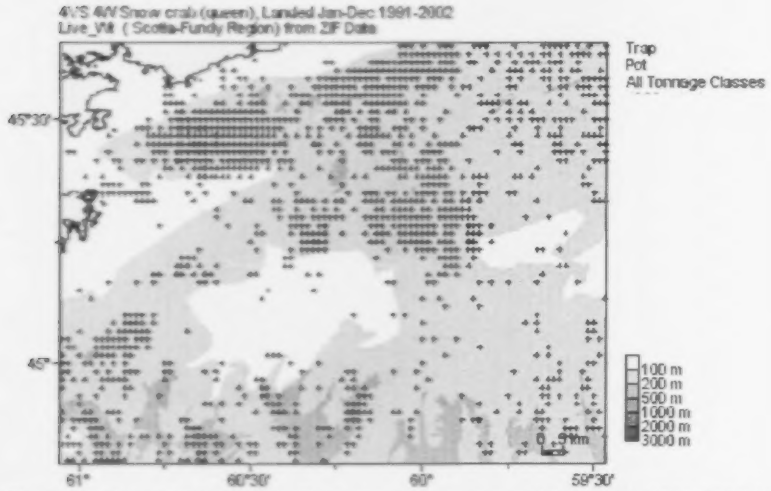


Figure 41. Areas in the Canso Bank area with snow crab landings, 1991-2002. No aggregation.

References (this section):

McCracken, F.D., ed. 1979. Canso Marine Environment Workshop. Fisheries and Marine Service Technical Report 834.

Harding, G.C., K.F. Drinkwater, and W.P. Vass. 1983. Factors influencing the size of American lobster (*Homarus americanus*) stocks along the Atlantic coast of Nova Scotia, Gulf of St. Lawrence, and Gulf of Maine: a new synthesis. Canadian Journal of Fisheries and Aquatic Sciences 40: 168-184.

Shackell, N.L. and K.T. Frank. 2003. Marine Fish Diversity on the Scotian Shelf, Canada. Aquatic Conservation: Marine and Freshwater Ecosystems 13: 305-321.

3.19.2 Western Gully

Location: Between Emerald and Western Banks.

Current Status: Closed to fisheries for groundfish (falls within the area closed to protect juvenile haddock).

Human Activities: Scallop fishing in some of the area, swordfish and tuna fishing in some of the area, shipping, research activities, MARLANT exercise area H3.

Criteria (1): Naturalness

Importance:

- Identified as ecologically significant as part of the Western Bank-Emerald Bank complex (see section 3.11).
- "Naturalness" of the area has not been studied.

Remarks: The Western Gully has been closed to fishing targeting groundfish since 1993 and fishing for groundfish using trawlers since 1987. There are few areas showing groundfish landings in the 1991-2002 period (Figure 42). There are scallop fisheries on the adjacent banks (Figure 43), but it is not a shrimp, surf clam or snow crab fishing area. There are landings of red crab and Jonah crab (Figure 44) from the shelf edge and slope. The Western Gully's potential naturalness has not been discussed in the literature. Remarks pertaining to other important features of this area can be found in section 3.11.

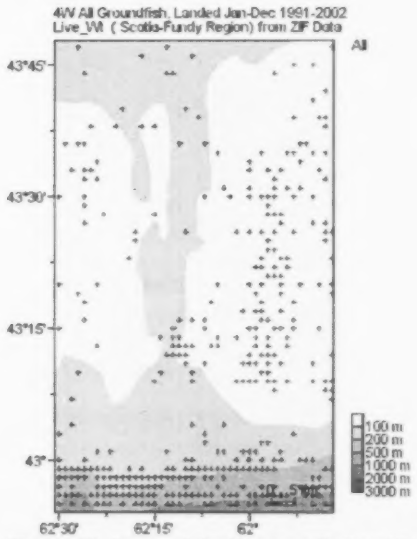


Figure 42. Areas of the Western Gully with groundfish landings, 1991-2002. No aggregation. All gears are selected; some reports may be landings of groundfish caught with scallop gear or non-bottom gear, particularly since the area has been closed to directed groundfish fishing since 1993.

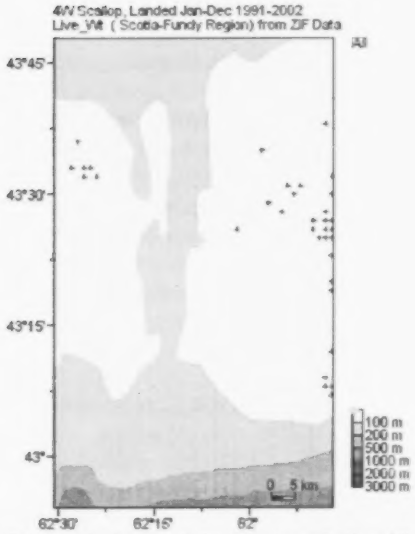


Figure 43. Areas of the Western Gully with scallop landings, 1991-2002. No aggregation.

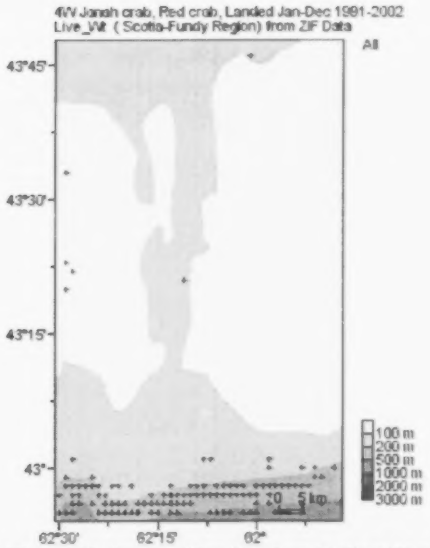


Figure 44. Areas of the Western Gully with red or Jonah crab landings, 1991-2002. No aggregation.

3.19.3 Areas of Misaine Bank

Location: Eastern part of middle shelf.

Current Status: Closed to fisheries for cod and haddock since 1993 (part of 4VSW closure).

Human Activities: Fishing (shrimp, snow crab), petroleum exploration, shipping.

Criteria (1): naturalness

Importance:

- Unknown. Few studies of the area.

Remarks: Much of the area has not been fished for groundfish in the 1991-2002 period (Figure 45). There is a shrimp fishery (Figure 46) and snow crab fishery (Figure 47) in deep waters in the area. It is not a red crab, Jonah crab, scallop or surf clam fishing area.

There have been few studies of that focus on the area. The Louisbourg line, a transect that is regularly sampled by oceanographers, crosses through this area. As a result, there is good information on temperature, salinity, and some other characteristics of the water column.

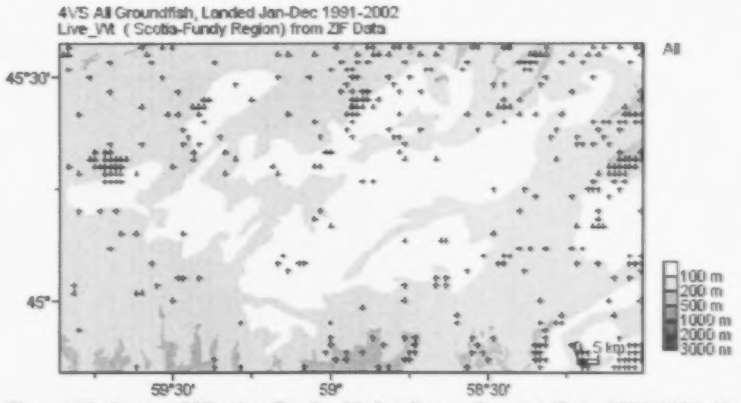


Figure 45. Areas of Misaine Bank with landings of groundfish, 1991-2002. No aggregation. All gears are selected; some reports may be landings of groundfish caught with shrimp gear or non-bottom gear, particularly since the area has been closed to directed fishing for cod and haddock since 1993.

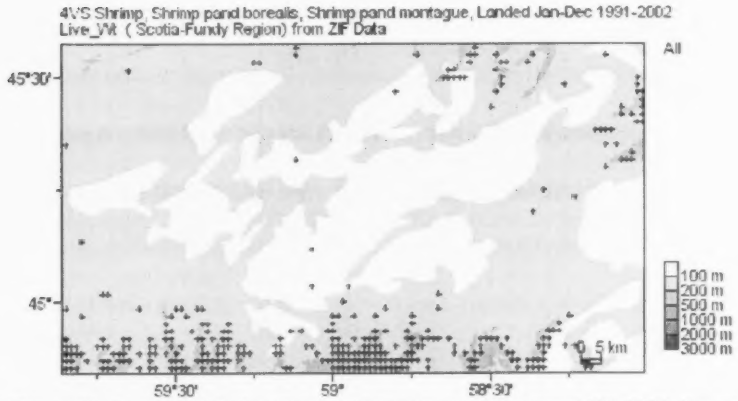


Figure 46. Areas of Misaine Bank with landings of shrimp, 1991-2002. No aggregation.

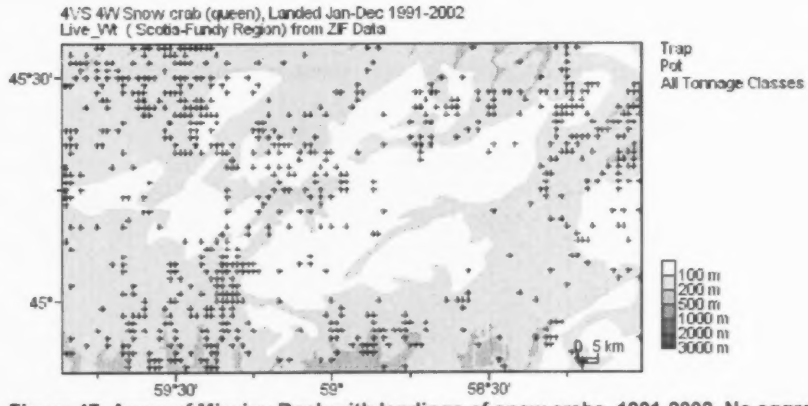


Figure 47. Areas of Misaine Bank with landings of snow crabs, 1991-2002. No aggregation.

4.0 DISCUSSION

The intent of this paper is to foster discussion on criteria for ecological significance and their application to the Scotian Shelf and Slope. Reviewing the literature on criteria for ecological significance and the literature on the Scotian Shelf has demonstrated that there are many areas that have been or could be considered ecologically important in some way. Some of these areas have restrictions on particular human activities with the aim of preserving or restoring the valued ecological attributes of the area.

While carrying out this exercise, it became evident that the amount of available information was a key factor in whether or not the criteria and indicators applied to sub-areas of the Scotian Shelf and Slope. In selecting indicators for each criterion, an attempt was made to pick indicators that corresponded to available information. However, for many of the areas there was little information available on a particular indicator and only areas with information could be profiled. It may be possible to substitute those indicators with others that address the same concept. For example, habitat heterogeneity has been suggested as an indicator of biodiversity for areas that lack complete information on species richness (see e.g. Roberts *et al.* 2003a). Although habitat heterogeneity was used as in indicator in this report, there is not a great deal of information on either habitat heterogeneity or species diversity (other than the diversity of commercial fish) for the Scotian Shelf and Slope. There may be other indicators that could be useful proxies for the criteria and indicators used in this document.

Better information is needed even for indicators for which there is information. For example, in order to appropriately assess the criteria of sensitivity, we need to know how activities impact particular species or habitats. While there has been an increasing amount of research on the impacts of fishing on species and habitats, there has been less research on some other activities. On the Scotian Shelf there is a particular need to study the cumulative effects of activities, for example the cumulative impacts of petroleum exploration. The cumulative effects of different human activities in a particular area should also be examined. For example, over the period of a few months a small area of the shelf could host seismic exploration activities, mapping of the sea floor using multibeam bathymetry, and fishing activity using fish finders. All these activities use sound in the marine environment (though not in exactly the same way) and we know little of the cumulative effects of these combined activities.

Despite the lack of information on some indicators, overall the criteria seemed to be applicable to the Scotian Shelf and Slope. It was possible to use the criteria and indicators to identify many areas of the Scotian Shelf that could be considered ecologically important according to the criteria, based on available information. However, some of the areas are very large, reflecting the scale of the information available. Many research activities on the Scotian Shelf have been carried out on a shelf-wide or slope-wide basis. For areas that have had dedicated research programs, such as Browns Bank and The Gully, the information available is much more detailed. For those areas, it may be possible to develop management programs that address small areas within the broader area.

Some ecologically significant areas may simply be large. Significant events or processes can occur on a very large scale, making it hard to identify particular geographic areas that are more important than other areas. For example, the shelf edge has consistently been identified as an area with elevated primary productivity. This large area has many different features and characteristics and is difficult to describe as a single unit. The slope in general is known to be an important overwintering area for many species of fish. Ecologically significant events or processes may also vary widely in location. For example, the areas of Western and Sable Island

Banks that have high densities of larval and juvenile groundfish may vary from year to year, depending on environmental conditions.

In some cases, it was difficult to identify which of two or three areas with similar characteristics was more important. For example, LaHave and Emerald Basins have been identified as areas with abundant krill and concentrations of juvenile and adult silver hake. There have been sightings of whales there and in the area south of the basins. However, there has been more effort to carry out research in Emerald Basin and there is more information for that area. Emerald Basin was profiled in this discussion paper because there was more information about its features. In another example, the depressions (shrimp holes) around Misaine and Canso Banks are depositional environments that support high concentrations of shrimp. However, no single depression stood out as more important than the others, and there was very little information on other characteristics of the area. Thus, all the shrimp holes were described together in one profile.

In several cases, areas with similar features were profiled. Three of the submarine canyons indenting the Scotian Shelf were profiled and other canyons along the Scotian Slope may also be ecologically important. Canyon researchers in other parts of the world have found special and unique properties in canyons as compared with adjacent continental slope areas. For example, researchers of canyons along the U.S. northeast continental shelf have found that communities within the canyons are different than those of the adjacent slope (see e.g., Cooper 1989). Of the Scotian Shelf canyons not profiled, Logan Canyon in particular may have significant features similar to the three canyons that were profiled. Its proximity to the three canyons used by northern bottlenose whales makes it possible that these endangered whales may occasionally be found there.

Coastal areas were not addressed in this document; however there are links between coastal areas and the offshore, with some coastal regions used as spawning and nursery areas, nesting areas, or seasonal feeding areas for generally offshore species. Some coastal areas appear frequently in the literature. For example, Chedabucto Bay is often noted as an important area for herring. They use it as a spawning, nursery and overwintering area (P. Lane and Associates 1992, DFO 2000). Fin whales frequent the area in winter when there are high concentrations of herring (P. Lane and Associates 1992). Other important locations often mentioned in the literature are the many islands along the south and eastern shores of Nova Scotia that are important nesting areas for seabirds (see Lock *et al.* 1994, Bird Studies Canada 2001, Breeze *et al.* 2002). The Significant Habitats: Atlantic Coast Initiative led by the Oceans and Coastal Management Division (Maritimes Region, Fisheries and Oceans Canada) is identifying and describing significant habitats along Nova Scotia's Atlantic coast.

Many of the areas identified as potentially ecologically significant are considered significant because of their value for commercial fish and invertebrate populations. Commercial fish are the best-studied group of organisms on the Scotian Shelf. Because there is better information for fish, there has been somewhat of a bias in profiling areas important to them in this document. However, many of the areas of value for commercial fish species may also be of value for other species. For example, the Stone Fence is of value to redfish and halibut fisheries because of concentrations of those fishes, but it is also an area where there are communities of deep sea corals.

Endangered species also tend to be better studied than the other organisms of the Scotian Shelf. Yet whether or not the conservation status of a particular organism is considered by COSEWIC has been inconsistent. Charismatic megafauna – such as marine mammals – are

more likely to be studied and thus evaluated. Marine invertebrates that live beyond the intertidal zone have rarely been evaluated by COSEWIC.

Areas highly used by two endangered whales that frequent the Scotian Shelf, the North Atlantic right whale and the Scotian Shelf population of the northern bottlenose whale, are fairly well-known. These areas have particular characteristics that make them attractive to species other than the whales. Besides being a seasonal feeding area for North Atlantic right whales, Roseway Basin is near an area of regular upwelling and heightened productivity on the shelf. Many other species are likely to benefit from this heightened productivity, including the concentrations of juvenile Acadian redfish found there.

The Gully is a key habitat for the Scotian Shelf population of northern bottlenose whales but many other species of cetaceans are also sighted in the area. The particular physical characteristics of The Gully appear to make it a preferred habitat for many whales and their prey.

The convergence of several criteria in some of the areas suggests that oceanographic processes and the physical structure of the environment are creating conditions that are attractive to many different groups of organisms. Species that are common over the shelf may be more concentrated in these areas at certain times of the year; species that are less widespread may be patchily distributed in some of these significant areas.

There are also indications of links between some of the significant areas. One obvious linkage is between The Gully and the Southwest Peak of Banquereau. The internal tides on the Southwest Peak may promote enhanced primary productivity that benefits populations found in The Gully. Another obvious connection is that between the three canyons of the northeastern slope of the shelf: The Gully, Shortland Canyon and Haldimand Canyon. All three canyons are frequented by the same population of northern bottlenose whales.

There are less obvious links as well. Fisher and Frank (2002) have found links between the fish populations of the Haddock Box (Emerald-Western Banks) and those of Browns Bank. The coral populations of the Stone Fence are upstream from populations in Haldimand and Shortland Canyons, The Gully, and the Northeast Channel. Little is known about reproduction in these animals and upstream populations may provide an important source of larvae to other areas.

Although there appears to be some convergence between the criteria and links between the areas of importance, this is not always the case. Little is known about The Patch and even the population of sponges for which the area is noted has been little studied. Overall, more research is needed to determine important areas for non-commercial species. Research is particularly important for species that are known to be sensitive to human impacts and for areas where new activities are planned. For example, it is important to identify areas with concentrations of pelagic seabirds and ensure that oil spills (including ballast water discharges) do not happen in those areas.

While this report profiled some potentially ecologically significant areas, ecologically significant does not necessarily mean sites for future MPAs. There is little known about some of the sites. In some cases, current management measures may be working well. In other cases, particular activities may not be appropriate or may not be appropriate at certain times of the year. It may be possible to address these activities through integrated management processes, such as the Eastern Scotian Shelf Integrated Management (ESSIM) initiative.

For all the areas profiled, boundaries were not well-defined. More thorough evaluations and assessments are needed to better understand the seasonality and geographic limits of the valued ecological attributes. Efforts to classify habitats of the Scotian Shelf will help in defining boundaries (see e.g. Kostylev 2002, Roff et al. 2003), although classifications may not be helpful for areas with little information. For areas where there is a great deal of information, classification of the area into units, according to ecological criteria, could be a useful next step. This could lead to the use of site selection software or expert opinion ranking systems to further define ecologically significant areas.

More research is needed on many of the potentially significant areas. For many areas of the Scotian Shelf and Slope, there is little dedicated research effort. This research should be a priority to ensure that the valued ecological features are being maintained. Yet there is a great deal of information on some areas, or at least enough information to support decision-making. Even for areas where there is little information on the natural environment, there may be a great deal of information on human activities. The amount and type of activity in potentially ecologically significant areas and the risk those activities pose to the valued features should be considered even when many details of the environmental setting are lacking.

REFERENCES
(not including references found with each profile)

Agardy, T. 1995. Introduction. In: T. Agardy, ed. The Science of Conservation in the Coastal Zone. IUCN IVth World Congress on National Parks and Protected Areas, Caracas Venezuela. Gland, Switzerland: The World Conservation Union. pp. 3-16.

Agardy, T.S. 1997. Marine Protected Areas and Ocean Conservation. Austin, TX: Academic Press.

Agardy, T., P. Bridgewater, M.P. Crosby, J. Day, P.K. Dayton, R. Kenchington, D. Laffoley, P. McConney, P.A. Murray, J.E. Parks, and L. Peau. 2003. Dangerous targets? Unresolved issues and ideological clashes around marine protected areas. Aquatic Conservation: Marine and Freshwater Ecosystems 13: 353-367.

Airamé, S., J.E. Dugan, K.D. Lafferty, H.M. Leslie, D.A. McArdle, and R.R. Warner. 2003. Applying ecological criteria to marine reserve design: a case study from the California Channel Islands. Ecological Applications 13: S170-S184.

Beck, M.W. and M. Odaya. 2001. Ecoregional planning in marine environments: identifying priority sites for conservation in the northern Gulf of Mexico. *Aquatic Conservation: Marine and Freshwater Ecosystems* 11: 235-242.

Bird Studies Canada. 2001. Maritimes IBA Network. Internet document. <http://www.bsc-eoc.org/iba/regional.cfm?region=MAR&lang=en> Accessed 23 July 2001.

Breeze, H., D.G. Fenton, R.J. Rutherford, and M.A. Silva. 2002. The Scotian Shelf: An ecological overview for ocean planning. Canadian Technical Report of Fisheries and Aquatic Sciences 2393.

Brody, S.D. 1998. Evaluating the role of site selection criteria for marine protected areas in the Gulf of Maine. Gulf of Maine marine protected areas project. Report #2.

Clapham, P. and F. Wenzel. 2002. Cruise Report, R/V Delaware II. Cruise No. DE 02-07. Large Whale Survey. 12 September 2002.

Cooper, R.A. 1989. Pre- and post-drilling benchmarks and monitoring data on ocean floor fauna, habitats, and contaminant loads in the Georges Bank submarine canyons. In: Walcoff & Associates. Proceedings of the North Atlantic Submarine Canyons Workshop. February 7-9, 1989. Volume 1: Synthesis Summary. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region. OCS Study MMS 89-0016. pp. 5-7.

Croom, M. and M.P. Crosby. 1997. Description of dimensionless analyses and delphic priority ranking methodologies for selecting marine and coastal protected areas. In: M.P. Crosby, K. Greenan, D. Laffoley, C. Mondor, and G. O'Sullivan, eds. Proceedings of the Second International Symposium and Workshop on Marine and Coastal Protected Areas: Integrating Science and Management. Silver Spring, MD: NOAA. pp. 108-109.

Day, J.C. and J.C. Roff. 2000. Planning for Representative Marine Protected Areas: A Framework for Canada's Oceans. Report Prepared for World Wildlife Fund Canada, Toronto.

DFO (Fisheries and Oceans Canada). 1999a. Marine Protected Areas Policy. Internet document. <http://www.dfo-mpo.gc.ca/canwaters-eauxcan/infocentre/legislation-lois/policies/mpa-policy/main_e.asp#toc> Accessed 11 August 2003.

DFO (Fisheries and Oceans Canada). 1999b. National Framework for establishing and managing marine protected areas. Internet document. <http://www.dfo-mpo.gc.ca/canwaters-eauxcan/infocentre/publications/docs/newmpa/index_e.asp> Accessed 11 August 2003.

DFO (Fisheries and Oceans Canada). 2000. 4VWX Herring. DFO Stock Status Report B3-03 (2000).

Dixon, J. and S. Pagiola. 1998. Economic analysis and environmental assessment. Environmental Assessment Sourcebook Update 23 (April).

Fisher, J.A.D. and K.T. Frank. 2002. Changes in finfish community structure associated with an offshore fishery closed area on the Scotian Shelf. Marine Ecology Progress Series 240: 249-265.

Gregory, R.S. and J.A. Brown. 1999. Ecological Criteria for the Evaluation of Candidate Fisheries Marine Protected Areas in Atlantic Canada. Prepared for Department of Fisheries and Oceans, St. John's, Newfoundland and Canadian Heritage-Parks Canada, Terra Nova National Park, Glovertown, Newfoundland.

Jamieson, G., and R. O'Boyle, co-chairs. 2001. Proceedings of the national workshop on objectives and indicators for ecosystem-based management. Canadian Science Advisory Secretariat Proceedings Series 2001/09.

Kelleher, G., and R. Kenchington. 1992. Guidelines for establishing marine protected areas. A marine conservation and development report. World Conservation Union (IUCN), Gland, Switzerland.

Kostylev, V., compiler. 2002. Proceedings of a benthic habitat classification workshop meeting of the Maritimes Regional Advisory Process. A Framework for the conservation of benthic communities of the Scotian-Fundy area of the Maritimes Region. Canadian Science Advisory Secretariat Proceedings Series 2002/023.

Laffoley, D., P. Coyne, G.C. Ray, and M.P. Crosby. Overview of group evaluation process, comments and results of the dimensionless analysis and delphic exercises. In: M.P. Crosby, K. Greenan, D. Laffoley, C. Mondor and G. O'Sullivan, eds. Proceedings of the Second International Symposium and Workshop on Marine and Coastal Protected Areas: Integrating Science and Management. Silver Spring, MD: NOAA. pp. 110-114.

Leslie, H., M. Ruckelshaus, I.R. Ball, S. Andelman, and H.P. Possingham. 2003. Using siting algorithms in the design of marine reserve networks. Ecological Applications 13: S185-S198.

Levings, C.D. and G.S. Jamieson. 1999. Evaluation of ecological criteria for selecting MPAs in Pacific Region: a proposed semi-quantitative approach. Canadian Stock Assessment Secretariat Research Document 99/210.

Lock, A.R., R.G.B. Brown and S.H. Gerriets. 1994. Gazetteer of Marine Birds in Atlantic Canada: An atlas of sea bird vulnerability to oil pollution. Canadian Wildlife Service, Atlantic Region, Environment Canada.

MCBI (Marine Conservation Biology Institute). 1999. Gulf of Maine priority areas workshop. Internet document. <http://www.mcbi.org/marineprotected/Marine.htm#gulf> Accessed 20 February 2003.

National Research Council. 2001. Marine Protected Areas: Tools for Sustaining Ocean Ecosystems. National Academy Press, Washington, D.C.

Nilsson, P. 1998. Criteria for the selection of marine protected areas – an analysis. Swedish Environmental Protection Agency. Report No. 4834. Stockholm: Swedish Environmental Protection Agency.

OCMD (Oceans and Coastal Management Division). 2003. A Strategic Planning Framework for the Eastern Scotian Shelf Ocean Management Plan (Draft Discussion Paper). ESSIM Forum Secretariat, Oceans and Coastal Management Division, Maritimes Region, Fisheries and Oceans Canada.

P. Lane and Associates. 1992. A Study to Identify Marine Natural Areas of Canadian Significance in the Scotian Shelf Marine Region. Project E-363. Prepared for Canadian Parks Service, Environment Canada.

Possingham, H., I. Ball, and S. Andelman. 2000. Mathematical methods for identifying representative reserve networks. In: S. Ferson and M. Burgman, eds. Quantitative methods for conservation biology. New York: Springer-Verlag. pp. 291-305.

Ray, G.C. and M.G. McCormick-Ray. 1995. Critical habitats and representative systems in marine environments: concepts and procedures. In: T. Agardy, ed. The Science of Conservation in the Coastal Zone. IUCN IVth World Congress on National Parks and Protected Areas, Caracas Venezuela. Gland, Switzerland: The World Conservation Union. pp. 23-40.

Roberts, C.M. 2000. Selecting marine reserve locations: Optimality versus opportunism. Bulletin of Marine Science 66: 581-592.

Roberts, C.M., S. Andelman, G. Branch, R.H. Bustamente, J.C. Castilla, J. Dugan, B.S. Halpern, K.D. Lafferty, H. Leslie, J. Lubchenco, *et al.* 2003a. Ecological criteria for evaluating candidate sites for marine reserves. Ecological Applications 13: S199-S214.

Roberts, C.M., G. Branch, R. Bustamente, J.C. Castilla, J. Dugan, B.S. Halpern, K.D. Lafferty, H. Leslie, J. Lubchenco, D. McArdle *et al.* 2003b. Application of ecological criteria in selecting marine reserves and developing reserve networks. Ecological Applications 13: S215-S228.

Roff, J.C. and S.M.J. Evans. 2002. Frameworks for marine conservation – non-hierarchical approaches and distinctive habitats. Aquatic Conservation: Marine and Freshwater Ecosystems 12: 635-648.

Roff, J.C., M.E. Taylor, and J. Laughren. 2003. Geophysical approaches to the classification, delineation and monitoring of marine habitats and their communities. Aquatic conservation: Marine and freshwater ecosystems 13: 77-90.

Salm, R., and A. Price. 1995. Selection of marine protected areas. In: S. Gubbay, ed. *Marine protected areas: Principles and techniques for management*. Chapman & Hall, London, UK. pp. 15-31.

Schaefer, H.L., D.M. McCullough, S.K. Johnston and D.R. Duggan. in press. Significant Habitats: Atlantic Coast Initiative (SHACI). SHACI Overview. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2649.

Shackell, N.L. and K.T. Frank. 2000. Larval fish diversity on the Scotian Shelf. Canadian Journal of Fisheries and Aquatic Sciences 57: 1747-1760.

Shackell, N.L. and K.T. Frank. 2003. Marine Fish Diversity on the Scotian Shelf, Canada. Aquatic Conservation: Marine and Freshwater Ecosystems 13: 305-321.

Turpie, J.K., L.E. Beckley, and S.M. Katua. 2000. Biogeography and the selection of priority areas for conservation of South African coastal fishes. *Biological Conservation* 92: 59-72.

Worm, B., H.K. Lotze, and R.A. Myers. 2003. Predator diversity hotspots in the blue ocean. Proceedings of the National Academy of Science, USA 100: 9884-9888. [Published online 7 August 2003. <http://www.pnas.org>]